



## WILDERNESS UNDER THE EARTH



# WILDERNESS UNDER THE EARTH

*by*

HERBERT W. FRANKE

*Translated by Mervyn Savill*

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# CONTENTS

<i>Chapter</i>	<i>Page</i>
1. INTRODUCTION	13
2. FIRST EXPERIENCES	16
3. METHODS AND EQUIPMENT	35
4. EXPEDITION TO THE TOTES GEBIRGE	52
5. THE ORIGIN AND DEVELOPMENT OF CAVES	70
6. TANTALHÖHLE—THE MOST DIFFICULT CAVE IN EUROPE	91
7. "THE HALL OF FANTASY"	107
8. GREEN LIMESTONE CAVES	118
9. CAVES AND THE SPECIALISTS	134
10. ICE CAVES	160
11. EXPEDITION TO THE GELDLOCH	184
12. PROSPECTS	199
SUBJECT INDEX	200
INDEX OF PLACE NAMES	202



## DEDICATION

*This book is dedicated to all those who still admire  
the marvels of Nature and appreciate the value of  
Man's efforts to discover her secrets.*



## ACKNOWLEDGEMENTS

MY THANKS ARE due to the trusty companions of my caving days, and to all those who read the manuscript and helped me to choose the illustrations.

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H. W. F.

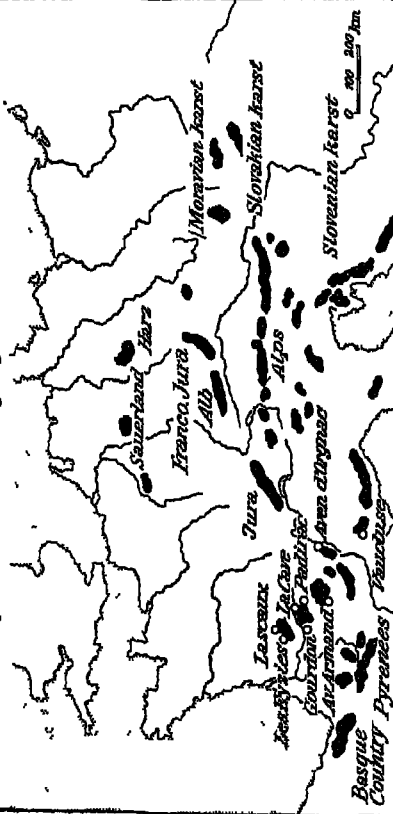


## MAPS AND PLANS OF CAVES

Map of Europe showing main caving regions	12
Little Peggau Cave	23
East foot of the Trageln (Totes Gebirge)	57
Tantalhöhle in the Hagengebirge	95
Katerloch near Weiz	108
The Schönstein Cave	130
Dachstein-Rieseneishöhle	163
Sectional plan of Dachstein-Rieseneishöhle	165
Eisriesenwelt (Tennengebirge)	167
Western Almberg Ice Cave (Dachstein)	175

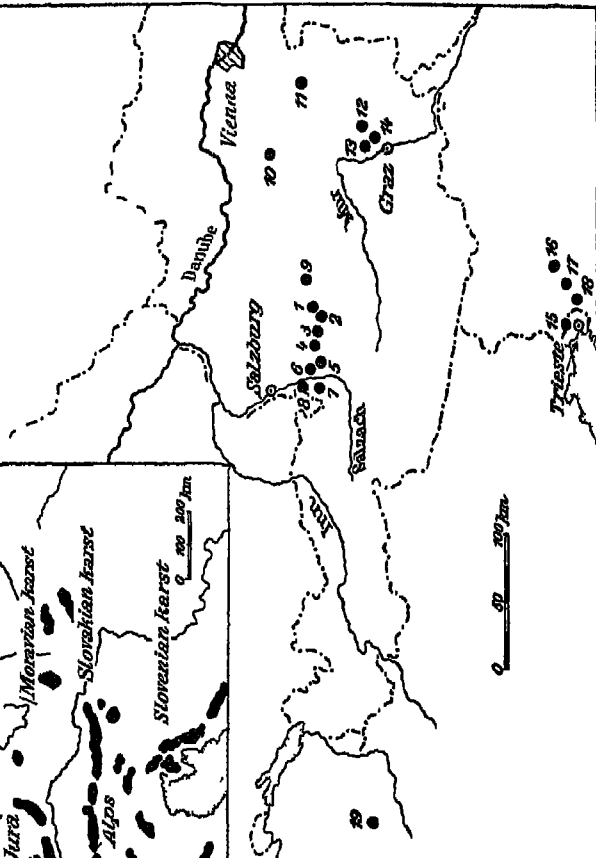


Map of the main caving regions in Europe



- 1 Almborg Ice Cave
- 2 Riesen Ice Cave
- 3 Mammoth Cave
- 4 Hierlatz Cave
- 5 Eiskogel Cave
- 6 Eisriesenwelt
- 7 Tantalhöhle
- 8 Bärenhöhle
- 9 Tauplitz Pothole
- 10 Geldloch (Otscher)
- 11 Hermann's Cave
- 12 Grasslöhle and Katerloch
- 13 Lur Grotto
- 14 Great and Little Peggau Caves
- 15 Riesenhöhle (Grotta Gigante)
- 16 Kleinhauselöhle (Malograpska jama)
- 17 Adelsberg Grotto (Postojnska jama)
- 18 Rujkva Caves
- 19 Holloch

Plan showing the Alpine Caves dealt with in this book



## *Chapter One*

### INTRODUCTION

THIRST FOR KNOWLEDGE and the need to explore are as old as mankind itself. Some urge drives us to pursue the mysterious and to discover its secrets. This urge leaves us no rest, enticing and luring us to the far corners of the earth, making inaccessible peaks and lonely islands goals for our deep, unsatisfied desires.

Such aspirations are doomed to grow dim and peter out in dreams and fantasies, for this is no longer the age of the pioneers and discoverers: we are slaves to the monotony of everyday life. Nevertheless, our age is not without adventure, although the picaresque is a thing of the past. Adventure has left the visible realms for a no less thrilling spiritual plane—science and technology. What is now being done in this field is more significant and of more consequence than all the historical conquests put together. And yet this new phase of evolution arouses in me a trace of sadness—a last spark of romanticism seems loth to die. In my opinion, a galaxy of active scientists and engineers cannot replace the individual adventurer, the man who stares danger in the face, whose courage we admire, whose urges we understand as fellow human beings and in whose deeds we can in a sense participate.

Although to-day the world has been thoroughly explored, there are still regions where no human has ever been, far from our civilization in Central Africa, South America, Australia and the Arctic. But for most of us they are too remote, and that, in the distant future, space-travel will afford us opportunities for discovery is no consolation. On the other hand, it was a great thrill for our civilized Europe, when by chance a man opened up to us an entirely new region close at hand—the ocean bed. To-day only a tiny strip of this realm has so far been

## *Wilderness Under the Earth*

explored; it is a world apart, a world with new—and for human beings—strange living conditions, and yet full of forms, creatures and beings in aspect and reaction entirely different from anything we encounter in our normal surroundings.

Unobtrusively, another revelation no less revolutionary and surprising than that of the ocean bed is taking place; that of the wilderness under the earth.

Caves have always been objects of superstition and reverence, places which simple folk have peopled with sinister creatures such as dragons, giants and mountain spirits—places where the adventurer in search of treasure risked his life. Even though the popular fear has vanished, the cave has remained a place of darkness—the physical darkness of underground passages and the psychic darkness of ignorance and mistrust. Very few people realize that they are places which are virtually unknown and the last truly unexplored land on our ancient continent.

Speleology, the study of caves, is no novelty, for it has been practised for three-quarters of a century, just as underwater exploration is not a new subject for research. There is, however, an entirely new feature in caving: it has changed from an amateur sport to a science. The scene of speleology—the bowels of the earth—is an unknown region which must be made accessible by the physical efforts of the individual. The branches of science involved have long since passed the pioneer stage and have now forced the speleologist to adopt modern methods. Co-operation between science and tourism, the alliance between primitive danger and subtle reasoning, the co-ordination of teamwork and individualism, of the community spirit and solitary experience, is hardly to be found elsewhere so closely interlocked.

I myself was originally attracted by the mysterious atmosphere of caves; accompanied by a single trusty companion and armed with the most modest equipment, I descended into the depths and was captivated by the originality of this strange landscape. I am still under its spell. From time to time it grows stronger; and then I long for the dark, timeless, world below the earth, and to study the problems of the changing face of the earth and of mankind whose fate is so closely bound up with caverns. Then I meet men of my own heart, enthusiastic cavers

### *Introduction*

who initiated me into their kingdom, invariably showed me something new and astonishing, men whom I have to thank for the profoundest and most beautiful experiences of my life.

Before me lies a pile of notebooks. The covers are open; they are stained with brownish clay and the leaves are crumpled and waterstained. From my first caving experience until to-day I have recorded all I have seen and experienced during many years in Austrian, German, Yugoslavian, Italian, French and Swiss caves. In my attempt to publicize the work of "cavers" I have constantly referred to these notebooks. What I wrote down—sometimes by the light of my acetylene lamp, among piles of debris and stalactites, sometimes on my return from the trip in a tent or in the train—will give a far better impression of the art of caving than memories which have paled in the course of time.

There is much to be said about caves, the methods of exploring them, the adventures to be met with in them and their connection with physical and spiritual life. I have, however, been obliged to choose a cross-section in order that my work in the underground limestone may be seen in its right perspective. I can only hope that my attempt will prove successful.

## *Chapter Two*

### FIRST EXPERIENCES

THE TRAIN RATTLED and jolted; the damp morning air seeped through the draughty windows and chilled us. My friend Alois Hach and I were the only travellers in the compartment and we had no intention of letting anything spoil our pleasure at having reached our longed-for destination. We leaned out of the window full of expectation. The train approached a rambling market village in the misty valley of the Mur. To the East it nestled against a steep wooded hill behind which the bare rocks rose abruptly to a mighty limestone wall; we had to crane our necks to obtain a view of the jagged peaks. From descriptions I had previously read, I recognized the Peggau Wall with its terraces and sheer escarpments, overhanging ledges, grass-covered buttresses and, in particular, the countless, yawning cave entrances. These are distributed over the whole area, sometimes in groups, sometimes isolated, many of them at the foot of the wall, but the majority higher up among the crags.

The engine sputtered and belched forth a stream of yellowish smoke. It slowed down. We collected our belongings and got ready to alight.

The valley lay in the early morning mist. We followed a small path which climbed steeply as it wound its way through the beech woods. We had left our luggage at the station and had set out with only our packs. The trees began to thin out and the ground was now dotted with large boulders. A stretch of undergrowth and the path suddenly led straight up to the wall at a much steeper gradient. ANYONE PROCEEDING BEYOND THIS POINT DOES SO AT HIS OWN RISK: we paid little attention to the signboard for, at the foot of the wall, we had caught sight

### *First Experiences*

of something black through the undergrowth. We were on the right track. We had reached the first cave entrance, a dark, crescent-shaped arc 20 feet wide and 13 feet high which seemed to invite us to approach. We entered a high, narrow antechamber. The green algae-covered walls fell away steeply at the back, leaving only a wide chimney on the left. We scrambled up about 23 feet, until a smooth steep rock face prevented any further advance.

Perhaps we could get up higher from outside? Climbing at the side of the entrance—it was easy because the rock had weathered into steps—we reached the back of the arc. Holding tight to the rock and, bending over the edge, we could see into the cleft which we had previously tried to climb. Other cave entrances some feet above us led into the overhanging rock face. It was inadvisable to start any fortuitous mountaineering here, if we wished to have time for the Great Peggau Cave.

We retraced our footsteps along the path which now turned south. Rocky steps led from one precipitous strip to the next in a steady ascent past stretches of rotting wooden railings. I accidentally touched one of the planks; it came loose and hurtled with the post into the abyss, breaking into fragments.

Soon the trees were below us, and we were still advancing in the shade of the wall when the sun's first rays rose behind the peaks, framing them with a gleaming border of gold.

After half an hour we reached a strip that broadened out into a rambling, roomy platform, and stood before one of the largest entrances which we had already spotted from below. It was one of the entrances to the Great Peggau Cave. The local inhabitants have christened it "The Frog's Mouth" on account of its bloated, yawning shape.

It was bitterly cold up there and the wind whistled in our ears. We sat down for a short breather and made preparations to enjoy our treat. Our acetylene lamps were filled, and we had brought water in a field flask. The little yellow flames were soon flickering in the wind. We were too impatient to rest for long, so I picked up my haversack which contained matches, torch, coloured chalk and other necessary trifles and followed Ali who had started off before me. Very cautiously we entered

## *Wilderness Under the Earth*

the cave. The darkness enveloped us so completely that for a few seconds we were totally blind. A few steps forward, feeling our way with our hands. . . . Were our lamps giving no light at all? The scree rolled underfoot . . . the stones gave way easily and made us slip sideways. At my side I heard a dull thud and a muffled cry. "What's up?" I asked. "Mind the roof or you'll crack your skull," came the irritated reply.

We went forward bent double. The acetylene flames soon conjured the outlines of our bodies out of the darkness and gradually our eyes grew accustomed to the contrast of light between the inside of the cave and the daylight outside. The feeling of insecurity underfoot persisted—the sliding scree, over which we skidded, slipped and staggered. A few more yards and a vague twilight appeared ahead of us; the gallery widened out into a huge chamber of some 700 square yards in area. The reflection we had noticed came from another entrance higher up to the south, and now a silvery shaft of sunlight flooded the cavern seeming extremely bright because our eyes had by now grown used to the dark.

A trifle overawed, we looked around us. The walls themselves were impressive enough. Countless smooth holes, the size of a man's fist, had been formed by erosion while between them towered stone formations, now saucer-shaped, now in spiral horns, sometimes protruding like handles—the walls would have been easy to scale had we felt so inclined. Here and there we could see horizontal fissures into which the light penetrated a few yards before being swallowed up in inky darkness.

"Hi!" called Ali from the eastern part of the hall. "Look what I've found—a bear bone." He was pointing a long object at an inscription, daubed in red paint on the artificially smoothed wall: "*Bear bones found here.*" He handed me his discovery. It was a brownish-yellow bone fragment which he had unearthed from the rubble. I weighed it in my hand almost with reverence. How many years ago could it have been since bears had lived up here?

We did not linger very long. The inner regions attracted us, so we crossed the impressive hall and came to a pile of rock fall which rose at an angle of  $45^{\circ}$ . As we climbed, the slope began to give way underfoot . . . pieces of rock became dislodged

### *First Experiences*

and rolled down the sides. A few more feet. . . . Careful of the light! . . . Too abrupt a movement could extinguish it . . . until we reached a height to which no ray of daylight came from the openings.

At last we had conquered the pile of debris and a small arch appeared. Now we could move with ease. The chamber narrowed into a kind of doorway leading to another chamber beyond.

Raising our lamps to get our bearings, we could distinguish a high, vaulted hall, with numerous pockets in the roof. The floor was covered with a well-trodden clay which bulged against the south wall in a 5-foot high cone. Behind this, a broad horizontal fissure led into a bare, cauldron-shaped chamber without egress. Its roof was reinforced by a massive limestone slab, upon which the next cavern rested as on a stage.

Ali climbed to the top of this damp clayey eminence in search of a handhold to hoist himself on to the slab. By a hardly visible projection he swung himself up over the ledge. "Follow me," he called, holding out his hand.

We pursued our climb. A clay slope fell sharply away from the next chamber, considerably higher up. To the left it had been washed away by water but by the right wall it led evenly and not too steeply upwards. I approached it very cautiously for fear of making the clay crumble. Slowly, inch by inch I gained height . . . the roof sank ever lower; I fell to my knees, and crawled on all-fours to the lowest spot—here, too, the clay ledge was at its narrowest. I lay on my belly, squeezed myself forward to the left, nearer to the crumbling edge, hoping that the material would hold. Fortunately, it did. Now that I was through, the roof rose; I stood up and called to Ali to follow, warning him to be very careful. The performance was repeated, the clay squelched but he, too, got through safely.

Our lamps were now burning perfectly and the low clay-filled room was brightly illuminated. This part of the cave was connected on the left with a second vaulted cavern of the same size; through a round hole in the floor we could see the upper part of the rubble slope.

We sat down for a short rest, but Ali was soon on his feet again with the cry: "Look! Bats!" He was right. One of them



### *Wilderness Under the Earth*

was hanging by its legs from a groove in the wall, its wings wrapped round its delicate body. As soon as we turned our lamps on the little beast, it crawled higher up the wall and we now saw that the domed roof of the chamber was covered with the brownish black creatures. Like Indian corn cobs laid out to dry, they hung there in their winter sleep.

After crossing this hall, we were unable to reach a few openings at the far end which sloped downwards. Turning east, we followed a gallery at the entrance of which loomed a tall stalagmite column which we discovered from an old caving manual which I had picked up by chance was called "The Watcher". After 20 yards we found ourselves in a blind alley and had to retrace our steps.

There were no difficulties in the descent except at the ledge above the clay cone. Ali felt below with his legs to find the top while I held up my lamp to give him some light. One foot touched the ground and the second foot followed: cautiously he transferred the weight from his hands to his legs and he had made it. Now he guided me down and I too reached the bottom safe and sound.

We soon reached the big hall. Our eyes, which had grown accustomed to the dark, could now hardly bear the light. It streamed in through the entrance and I had the impression that we must breast this flood of light before we could emerge into the open air.

Soon we were standing outside, dazzled by the sun and making a great effort to return to reality: the idyllic eyrie of the rocky platform, the narrow path leading to it, and far below us trees, houses, fields and the river.

\*       \*       \*       \*       \*

By this time it was midday. We unpacked our sandwiches and discussed what we should do next. Consulting my diary, I read out the following observations taken from the old caving manual:

At the north end of the terrace there is a fair-sized cave opening which gives access to the Little Peggau Cave. But if the strip of rock which debouches from the south on to the terrace in front of the Great Peggau Cave is crossed, a broad entrance which leads into the cavern will be reached after a few feet of climbing.

## *First Experiences*

We could not afford to miss this opportunity, but where were the two entrances? We searched the northern end of the platform but found no trace of an entrance. Had the author made a mistake? Perhaps he had meant the southern part of the plateau. Here, too, we had no success so we retraced our steps. We took stock of our surroundings. A dilapidated breast-work barred our passage to the north. Climbing over it, we discovered a crevice in the mountain, but it turned out to be filled with rubble. Again there was no entrance. A few yards ahead the flat ground fell away steeply, and Ali bent forward to inspect it. "This must be it," he said. The terrace narrowed into a ledge, about a foot wide, which ran along the wall with a steep drop on the valley side.

"I'll try it," said Ali. "Hold me on the rope!"

With mixed feelings I fastened the sling round his body, but I could find no point of support to gain a good foothold. Ali, however, refused to be thwarted, and hugging the wall he circumnavigated the abyss . . . the first scree bank was 90 feet below. His fingers explored the rock face for holds but it was smooth. Ali was unruffled but I could see the muscles working on his temples. He progressed inch by inch until he disappeared behind a buttress. I could still hear the gravel crunching under his hobnailed boots.

It seemed an eternity, and I wanted to call out but refrained from doing so for fear of distracting his attention. Finally, his voice was carried to me on the wind: "There are a few holes here, but they don't lead far in. Shall I climb up a bit?"

"No," I shouted. "I can't hold you here."

The minutes passed. At last a hand appeared, followed by a foot and then by his whole body. Another couple of steps and he was safely back.

I breathed with relief. "This can't be the right spot," I said. "Where is the entrance the book mentions?"

Ali shrugged his shoulders and slipped out of the rope. I re-read my notes, and then followed the path down a few feet, but there was no sign of the Little Peggau Cave.

We did not give up hope of finding it and decided that later we would ask for information locally.

But I was not entirely satisfied. Once more I scanned the

## *Wilderness Under the Earth*

terrain, studied the rock faces on both sides above me, the narrow, weathered ledge and the crevice in the cliff next to the abyss. The boulders were really wedged into it and I wondered if this were not man's handiwork. I pulled a few out, revealing new fragments of rock. The back of the niche was not closed; a tube concealed by boulders led into the mountain.

Ali now gave a helping hand. We removed our coats, rolled up our sleeves and were soon sweating profusely.

At last most of the stones had been removed and I could crawl about a yard inside, though here the passage narrowed and I had to lie on my belly. There were still stones in the way; I had either to push them aside or pass them back to Ali, who got rid of them.

"Give me the lamp," I said. It rapidly grew darker inside and my body was stuck like a cork in the tube. The ground was covered with jagged scree, which bored painfully into my knees and elbows. I pressed forward with my toes . . . two, three, five yards . . . and then suddenly the roof rose. In my delight I stood up, for my back ached from the cramped position, but I had been a little premature and the joke was on me: I banged my head on the roof and saw stars. Something clawed at my legs. . . . I gave a start and lowered my lamp, but it was only Ali, who had followed me in his impatience. He was panting from the effort and the beads of perspiration on his forehead glistened in the light of the acetylene lamp.

"Mind your nut," I said, but he merely laughed.

He was wearing a thick fur cap which he had brought along to protect himself from the cold and the wind; it turned out to be an ideal protection against knocks on the head.

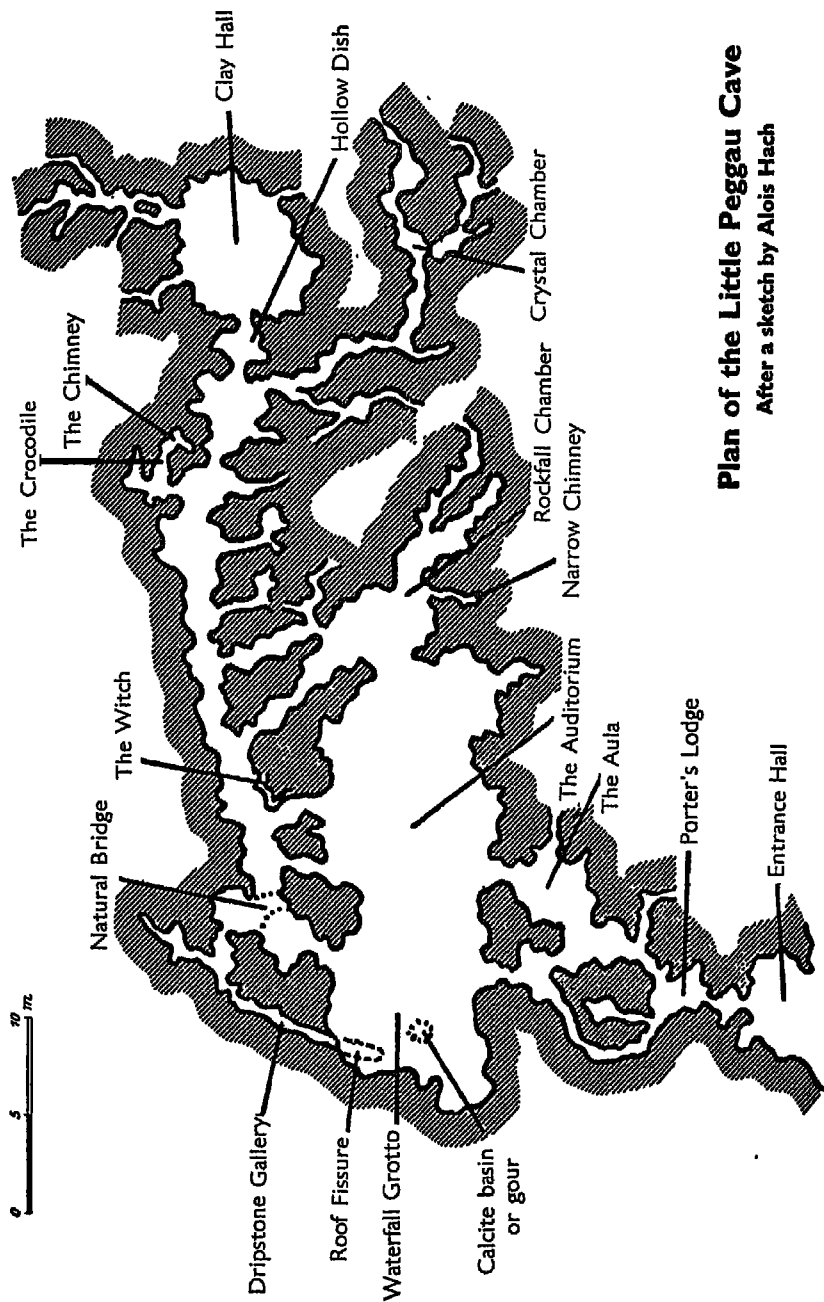
In high spirits, we squatted in the low-ceilinged chamber, which we christened "The Porter's Lodge". The real reason for our gaiety was that several holes opened out of it. We had obviously hit upon a cave system of considerable size.

"Which passage shall we take first?" asked Ali.

"This one," I replied.

"But that's the one we have just come out of."

"Take a look at your watch," I said with a laugh. "It's past nine o'clock and it must be pitch dark outside. We'd better start for home. That path is far too dangerous in the dark."



**Plan of the Little Peggau Cave**  
 After a sketch by Alois Hach

## *Wilderness Under the Earth*

We crawled out hurriedly, thinking that to-morrow was another day.

Next morning at dawn we hurried up the mountain and did not call a halt until we had reached "The Porter's Lodge". We chose the largest passage and bent double, we entered it, disturbing a host of bats that were hanging there head downwards. The roof was very irregular and from time to time we were forced to crawl on account of projections. A dull roar came from ahead of us and we hastened our steps.

The way suddenly broadened out. We had entered a very spacious hall which our lamps barely illuminated. Here and there, however, I could distinguish vague black patches, darker than their surroundings—obviously entrances to other passages.

Ali had hurried on ahead. I was about to follow him when I suddenly remembered that we must mark the entrance or else we should not find the way back. I stood there for a moment watching the rays from my lamp dancing round the hall, lighting up new parts of the darkness. The shadows flickered and leapt to and fro, and the cone of light lingered for a moment on a rubble-covered floor, jagged boulders, towering arches and spongy, eroded patches of roof.

Ali gave a shout of delight, telling me to come at once. I marked my position with red chalk and hurried after him. He had discovered the origin of the roar we had previously heard; from a rift in the roof, covered with snow-white calcite, straw stalactites hung, and water, throwing up a cloud of spray fell into a rimstone basin of about a square yard in area. It was full of water, clear as crystal, rippled by the falling drops.

It was a bizarre world and new wonders lay in wait for us at every turn. But it would have been fatal to allow ourselves to be carried away in our enthusiasm: this system was a labyrinth and a visit to it demanded a clear head. Ali took out pencil and paper, and drew a rough plan. As we progressed he would complete his drawing so that we should have certain landmarks for our return journey.

We crossed the full length of the hall. It ended in a joint-fissure, closed on the right, but on the left giving access to a

### *First Experiences*

broad passage. To one side above our heads hung a sinister image that, when we lit it up, turned out to be a jagged boss of rock which bore an amazing likeness to an old woman's head, with a grinning mouth and one half-closed, globular eye. We christened it at once "The Witch".

On turning to the left, we ignored two low-roofed tunnels, for a magnificent natural phenomenon met our eyes. Over the passage ran a natural bridge which might have been hewn out of the rock by a sculptor. There was a roar of water behind it, and Ali rushed on ahead of me under the bridge. I heard Ali curse, and followed rather more cautiously, holding my lamp before me. A figure approached me—it was Ali asking for a light. "What happened?" I asked.

We had come round in a circle without being aware of it and had returned beneath the bridge into the great hall at the precise spot where the water dripped into the basin. A drop had extinguished Ali's lamp and, after taking a few steps in the dark, he found himself standing with both feet in the basin. But this little mishap did not in the least damp our spirits. Ali drew the side passage and two small communicating tunnels on his plan and we set out on a thorough exploration of the parts to the right of "The Witch".

The passage ran steeply uphill; one or two of the branch tunnels turned out to be impasses, and the space between the walls became higher and narrower. Above us in the wall to the left was a broad opening.

It was not difficult to reach, for the wall was rough and fissured. Ali lit the way for me. I came to a broad ledge, found handholds, and advanced step by step until I reached a 6-foot high smooth patch. Feeling the wall above with my right hand in the deep shadow, I discovered a sharp edge round which my fingers fitted comfortably. I began to hoist myself up when the rock gave way and I was on my back among the boulders below. It had all happened in a flash. My hip hurt and I felt dizzy. Rubbing my limbs, I discovered that I was still whole, but I had fallen on a pointed stone and given myself a nasty gash; my head began to ache and I was still slightly dazed. Now I discovered that I had grazed one of my palms and fumbled for a handkerchief. I felt a big hole in my trouser leg, but could

## *Wilderness Under the Earth*

not use the handkerchief to stop the bleeding because it was stained with clay and mud.

We squatted on our haunches against a rock and took a rest. Ali unwrapped a bar of chocolate, but I had no appetite.

My thoughts were gloomy as I chewed the chocolate, but after a few moments I began to feel better. This accident had taught me a lesson which I was never to forget: *Never move about in a cave except with the utmost caution.*

I think that Ali had also learnt by my experience. It did not, of course, prevent him from trying the climb himself, but he tested every hold meticulously to discover loose stones. Fragments of rock came tumbling down, tinkling like potsherds. His ascent was slow, but at last he reached the ledge and bent down to take the lamp I handed up to him.

"It's quite easy from here," he cried.

I thought that "easy" was perhaps an understatement. His shadow glided light as a feather over the wall, but the body which scrambled higher between the rocks was waging an arduous struggle against the forces of gravity, as I could hear from his stertorous breathing. Fragments kept falling down until I could see no more than a faint glimmer of light, which eventually vanished. Now all that I could do was to listen to the light rustle of his clothes on the rock face.

Fortunately, Ali's little trip did not take very long, but I was very relieved when he stood once more at my side on terra firma. He had the advantage of being an experienced mountaineer.

Now the natural tunnels through the mountain lay ahead of us. After our scramble, progress was comparatively easy, although at times we had to crawl on all-fours to negotiate steep steps.

A narrow fissure lay to our right and we had to overcome a difficult obstacle in the shape of a 6-foot head-high step coated with wet clay. The only possibility of scaling it seemed to be by hugging the left wall. Here the platform levelled out and I made an attempt. The clay was very slippery and Ali pressed my shoes with his hands against the steep slope. Slipping and sliding, I swayed over to the right where the next procedure began; now I had to lie full length in the clay to make as large

### *First Experiences*

a frictional surface as possible, while Ali leant with his whole weight against the clay wall to hold me. Now came the last and steepest stretch. Digging my fingers into the clay, I pulled myself up until my head and shoulders were above the ledge and I could obtain a good hold. I wriggled my legs gradually to one side so that I could lie full length above and at last I could stand up. In a sitting position I now swung a leg over a rocky spur so that Ali could catch hold of it, and this meagre support enabled him to clamber over the obstacle and join me.

This new region had its own macabre charm. It was surprisingly warm and smelt musty; clay was everywhere, and voices were muffled, for the clay deposit on the floor, walls and roof absorbed any echo. There was no colour here but a monotonous muddy brown. Our shoes were soon shapeless lumps of clay; our clothes were plastered with clay and even our faces were coated with it.

Now it was time to turn back. We made a note of a few chimney-like openings overhead, but we could see that these were inaccessible—at least for the present. We intended to return better equipped than we were that day.

In turn we slid down the wall on our backsides and tramped back, leaving a trail of clay behind us.

It was midday and time for lunch. We ate it by the light of two torches in order to save our carbide supply, made ourselves comfortable on the pile of debris in the great hall, and quenched our thirst with the ice-cold water from the calcite basin.

Refreshed and full of energy once more, we felt ready for anything. We could not find a better goal than the opening above the natural bridge not far from the rimstone pool. There was no difficulty in climbing on to the span, but once there it was uncomfortable. The rift lay only about 3 feet from our position on the bridge, but between it was a smooth wall which descended vertically another dozen feet into the chasm. Moreover, the smoke from our torches was a hindrance, because it collected under the cave roof, hiding everything in a murky cloud.

Below the joint rift I noticed a ledge which would offer a safe halting place and we aimed at this, but first we had to make a rather long crossing without the aid of our hands. Ali went



### *Wilderness Under the Earth*

first and reached his goal, but since there was not room on the ledge for both of us, he squeezed himself into the crevice and turned round in readiness to catch me. This, however, proved unnecessary, because I too made a safe crossing.

Ali now hurried on ahead and I followed close behind. The narrow cleft ran slightly uphill, but the smoke grew thicker and I heard my friend cough; nevertheless, we refused to be defeated and plunged forward into the smoke cloud. Ali had another fit of coughing and I found it difficult to breathe. My eyes watered. With the best will in the world it was impossible to continue and we were forced to turn back.

Some hours later we returned to the same spot to find that the smoke had evaporated. This time I was leader. I squeezed between the walls, which were not much more than 8 inches apart, until I came to a heavy chocked slab which only touched the wall at two places and gave me the impression that it might topple at any moment. But I had to pass beneath it and I took the greatest pains not to touch it, so lying on my side I worked my way forwards. Suddenly the floor sloped downhill; the fissure narrowed again and a hole about 20 inches across appeared. I advanced a little further with the lamp held out as far in front of me as possible, but it was no good, for nothing but darkness seemed to lay ahead.

Behind me Ali asked impatiently why I had stopped. I told him, but he could not control his impatience. He rolled over on to his side in the cleft and crawled forward until he was 3 feet higher and could see over my head. It was obviously a very deep shaft. Head first, I slipped a little down until I noticed that the walls started to overhang, so I stopped and shone my torch downwards as deep as possible, but could still distinguish nothing. At the spot where the overhang began, however, I could make out a dripstone ring festooned with a close-set line of pure white stalactites.

We now needed the rope and Ali went off to fetch it.

Time seems interminable when you have to wait alone in a cave in the dark. The trouble is the inactivity which makes you begin to think of things which in the ordinary way would never enter your head. The rock in contact with your skin is icy cold; the damp penetrates through your clothes to your

### *First Experiences*

knees and shoulders; the silence weighs on you like a heavy burden and the darkness is as impenetrable as black ink. You hear the ticking of a clock which, for no apparent reason, seems alternately to hurry and then to slow down, but it is only water dripping from a stalactite. The corners into which the light of the lamp does not penetrate become, without one having realized it, huge caverns which stretch to infinity, and the shadowy, unilluminated surfaces suddenly seem to be swaying in space without support until one hurriedly moves the lamp to banish the mirage.

Ali had hurried. He handed me the rope, but I hesitated. "Let's lower the lamp first," I suggested. Ali secured it and slowly lowered it into the shaft. A rocky floor appeared in the circle of light. The torch touched bottom at perhaps 20 feet. Another huge cave! Obviously we must descend into it, but some instinct warned me.

"Go back to 'The Witch' again," I said, "and call to me at regular intervals."

Ali did as I asked. Tense and excited, I listened for any sound from the cave below. Not a sound! I could only hear the calls coming from behind me: "Now I'm under the bridge; I'm on my way to 'The Witch'. . . . Standing by 'The Witch'. . . . Entering the traverse."

"Come back," I shouted to him. "I can't hear anything down there."

There was a moment's silence while I prepared a running knot.

Then I shouted down into the cave, where a light had suddenly appeared: "Is that you, Ali?"

"Of course it is. Where are you speaking from?"

"From up here. Where are you now?"

"Just by the calcite basin," he replied and added: "Now I can see your lamp too. There is a hole in the roof which we had overlooked."

I still cannot understand how we came to cross "The Waterfall Grotto". I could have sworn that we had been going in the opposite direction. I made a mental note that in future I would always take a compass with me. Another thing I could not fathom: why had we heard no sound of dripping water from above?

## *Wilderness Under the Earth*

The problem was solved once we were below, for the water had in the meantime stopped dripping. Was it the frost that had stopped the flow or were there other causes?

What should we undertake next? I suddenly remembered the fissure we had found just before midday when we discovered "The Clay Hall". To complete the day's work, we decided to explore it thoroughly.

It was a tight squeeze and with difficulty I forced myself inside. A turn and then a second, after which the roof lowered and I had to lie flat. This stretch was the narrowest, though fortunately the roof soon lifted and I could struggle to my knees. My lamp had grown dim presumably for lack of carbide, but it would suffice for this short stretch. A few more steps and I entered a small chamber from which the narrow passage seemed to continue in the same direction. I forged ahead and stumbled over a boulder. There was a faint glimmer and I bent down, not daring to trust my eyes. The whole fragment of rock consisted of crystals—glassy, transparent, elongated prisms. How had it ever got there?

I shook my lamp to increase the flow of gas and pointed the beam at the walls, and now I could see that they were completely covered with crystals and that the lump of rock on the ground was merely a fragment that had fallen from the roof. Rows of crystals firmly encrusted the walls; the surface of this crystal layer was terraced and fluted, covered in places with a thin layer of clay, giving it a slightly yellowish colouring.

Ali was close behind me and his acetylene flame was still burning brightly, filling the chamber with light. In a flash we were among a host of stars, and the crystal facets reflected the light a thousandfold. Each movement of the lamp lit up new areas. We were speechless. Tired, filthy and in our torn clothes, we stood side by side without uttering a word, yet realizing that fortune had smiled on us, allowing us to discover the magic of this forgotten region deep in the bowels of the mountain. Both of us felt too, I think, how fortunate it was to be able to share such an experience with a companion.

We lost all sense of time, and when at last I came to my senses, I understood those fairy tales of men who were led into

### *First Experiences*

grottoes by some spirit of the mountains to show them its marvels. They, too, lost all sense of time, and when they returned to the outside world, the neighbourhood was strange and all those they had known were dead, because they had not been there an hour or two but for a century.

Something crunched beneath my feet. A piece of crystal as big as a fist had broken off and the new break gleamed softly like mother of pearl. We decided to take it with us as a souvenir, but how could we bring it back undamaged? Finally Ali took off his fur cap and wrapped the treasure carefully in the lining.

We had had enough for one day. We left the cave without a word and we were still silent when we reached the foot of the wall. It was about half an hour to dusk. We could not possibly enter the village in the state we were, for we looked as though we had been wallowing about in the clay; our clothes were ripped to shreds; Ali had lost the sole of one boot and was limping; our faces and hands were covered with scratches.

We sat down in a sheltered spot among the beech trees and waited for nightfall.

\* \* \* \* \*

We remained five days at Peggau that year. Of the fifty caves in the Peggau wall, we visited no more than two during our first four days: the Great and the Little Peggau Caves. On our last day we visited the Lur Grotto.

Not far from Semriach, a charming market town nestling in the mountains, the Lur River runs through a broad dale until it comes to an obstacle, a 236-foot high cliff. The water hollowed a way out through the mountains, gradually broadening the fissures and clefts into a subterranean channel. It came out into the daylight again two miles further north in Peggau, but the soluble power of the water continued to attack the rock until the river bed gradually deepened. To-day the water flows along another path, which is still unknown. Its resurgence was first discovered in 1952; it is the Hammerbach spring at the foot of the Peggau Wall.

The cave guide and blasting expert Karl Wiesler showed us the Peggau section of the cave of which he was in charge at that time, and later I often met Wiesler, usually when it was a

## *Wilderness Under the Earth*

question of crawling on one's belly to explore difficult cave systems. With him I made the descent into Pothole XVII of the Tauplitz Plateau, and I once spent a night with him a thousand feet below the surface at the half-way post of the Ötscher Ice Cave.

The Lur Grotto has been opened to the public at both ends. Between the parts which have been made accessible to tourists lies a stretch that has been left in its natural state for about a mile, and this can only be crossed by "cavers" who are prepared to scramble and climb.

With Wiesler we visited the Peggau section of the cave.

At the pull of a switch, a galaxy of electric lights went on. After our daily crawling in the squeezes of the Little Peggau cave, it was most impressive to see these broad galleries, as wide as underground tunnels, but still preserving the wild and indefinable atmosphere of the cave world.

The path was kept scrupulously clean and level and the inclines had been tarred. After about 55 yards we entered an artificially built gallery which curved twice to the left before we reached a vast hall from which the artificial stream-bed issues, and then followed a series of lofty caverns, not to mention countless side caves. At that time it had only been possible to open up a small part of the cave and all the branch galleries remained untouched.

The principal feature of this series of rooms is the wealth of dripstone adornment. The visitor continually comes across mighty stalactites on the roof, some thick and segmented, others slim, smooth and gleaming blue or red. They seldom hang down singly from the roof but are in groups, and may be found in pairs, in tens, and some times in hundreds. Here are clusters like many-tentacled fabulous monsters, there fluted curtains flush with the wall or billowing into rows of fringes and tassels, while some distance away organ pipes reach down to the floor. Here Nature has given free rein to her fantasy. The forms become ever more intriguing and the human imagination has likened them to various objects of the outside world: "The Little Organ", "The Böcklin Fountain", "The Three Spires". But many of the names reflect the fairy-tale impression which these plastic images conjure up: "The Witches' Door",

### *First Experiences*

"The Enchanted Forest", "The Fortress of the Holy Grail". We stood spellbound in front of "The Giant Palm"—a whitish calcite formation which descends from a cleft in the roof, pot-bellied at the top like the armour-plated stomach of a primeval monster and tapering into a seam of hundreds of 3-foot long stalactites—or to be more accurate, helictites because their tips all bend slightly towards the wall. We climbed the three hundred steps up to "The Blocksberg", an underground hill about a furlong in length and of a height which it is difficult to estimate. We passed row after row of niches full of transparent stalactite straws. "We call them 'Glass Rain'," said Wiesler, and no better nickname could have been found for this remarkable phenomenon.

Soon we came to a building site: empty cement sacks lay on the floor and pails stood by the wall.

"At present this is the end of the guided path," said Wiesler. "We are in the process of opening up the stretch as far as the Zierhutsee, the largest underground lake in Austria. It is about one and a half miles from the entrance."

One and a half miles!

For the first time we realized that we ourselves were already more than a mile away from daylight. We had followed an easy path in the vitals of a mountain where every transverse cleft can make a man lose his way and where the unknown lurks behind every hole in the roof. The floor on which we trod had been flattened and terraced, but once this stretch, too, must have been unexplored. Men must have visited these vaulted caves for the first time, wading through the river bed, clambering over boulders and up walls, ever further, ever deeper into the mountain, with no contact with the outside world. When did this happen, and who was the lucky discoverer? Has the cave now been fully explored or are there still undiscovered parts? Are there other caves of these proportions or is the Lur cave unique, the result of a special set of geological circumstances?

These were some of the many questions which Wiesler was only too pleased to answer, for he knew every corner and every rock in the cave. He described the first trips which he knew only from hearsay and spoke of the problem nearest his heart—that of making it a tourist centre.

### *Wilderness Under the Earth*

In his tale Wiesler conjured up the old heroes of the Lur Grotto. We could follow them on their voyages of discovery, see them rowing downstream in their boats and share the delights and agonies that the cave must have held in store for them.

We strolled back leisurely towards the entrance. Once more we passed the bizarre calcite formations, the most impressive illustrations imaginable to Wiesler's lecture.

He went on to speak of the history of the cave, of the experiences and adventures in 1894 of the first rash men when the Semriach entrance was discovered by members of the Styrian Caving Society and how ten of them, as a result of a flooding of the Lur, had to remain ten days on a narrow, water-lashed ledge before they could be rescued by sappers. He told us the story of the Salzburg speleologist Poldi Führich, who, for some unexplained reason, fell from a 65-foot ladder to her death; of the systematic exploration instituted by Councillor Bock, under whose leadership the Graz Caving Club, starting from Semriach, came to within 550 yards of the Peggau entrance, but had to turn back because the last stretch was filled with water, and of the first complete crossing achieved by Gangl and his team from the same club.

We were on the way home. Outside the lights twinkled and a deep blue sky lay over the mountains.

My five days in Peggau had given me more experiences than I had had for the rest of the year. Everything was still vivid in my mind, and when I closed my eyes I could see rock formations, calcite figures, and glittering crystals; clay floors glided past and the carbide flame smoked and flickered.

Ali must have felt the same. Gradually our tongues loosened and we retraced every step in our mind's eye. We discussed the stretches we had covered together, pointing out details which one of us might have missed, asking each other questions to which we could now only guess the answers. And gradually we succumbed to our weariness. Imperceptibly we entered the realms of meditation and dreams, figuring out future trips and making plans.

The magical atmosphere of the world below the earth had achieved its effect. Should we ever be able to free ourselves from its spell? Should we ever wish to do so?

## *Chapter Three*

### METHODS AND EQUIPMENT

PEGGAU WAS MY first serious caving experience. Since then I have explored more than a hundred caves, many of which were larger, deeper and more beautiful, but in none of them have the impressions to be obtained from virgin depths remained more deeply engraved in my memory than the Little Peggau Cave. There I succumbed for the first time to the enchantment of the boundless subterranean world of caves—and it was more than the mere attraction of a novelty. Time and time again I have been overwhelmed by that strange mixture of embarrassment and anticipation as soon as I leave the beaten track and penetrate into the depth of the earth by the light of my acetylene lamp. This enthusiasm is, of course, a most important premise for a successful speleologist. But one other thing is just as important—the equipment.

The alpha and omega of any caving adventure is the lighting equipment. My permanent equipment, which I have never had cause to revise, consists of the following objects: an acetylene lamp, a ready-to-hand full box of matches, a second box wrapped in silver paper, a few single matches and four unused match-boxes packed in a shallow water-tight tin. Add to these a candle, a torch with a spare bulb, a battery in water-proofed packing and, when possible, a spare tin of carbide.

I discovered how important all this equipment is in the Freisloch, a pothole near Winzersdorf in Lower Austria. With a few comrades, I entered one of the upper chambers. I lent my torch to a friend who had brought no lighting equipment with him, and I myself then scrambled on my own about a hundred feet down some side chimneys to the bottom of the pitch. Once below, I looked round at my leisure, took photographs and with no foreboding prepared to make the return



### *Wilderness Under the Earth*

trip. From the floor of the cavern I had to climb a 10-foot high, slightly overhanging ledge which had enough handholds to allow me a comfortable ascent. Following this was a clay-covered notch rising at about 70° in which the holds were few. Lying on my stomach, working my way from one to the other, and, sweating profusely, I gained about a dozen feet. Then, as the result of a clumsy movement a deep breath from me blew out the acetylene flame. It was pitch dark and I had no handhold. I felt myself sliding slowly but surely. It was useless looking for holds because it was impossible to find them in the dark. Inch by inch I slipped deeper, feeling feverishly for my matches. Soon I should reach the ledge above the chasm. To light the lamp, I needed both hands. For a second I raised my elbows to check my descent down the groove—by now I was slipping faster—and struck a match. It lit. I grasped for a joint in the rock face which now became visible and I was saved, but my legs were already dangling over the abyss. This experience most certainly taught me an important lesson.

I once took the trouble to prepare a list of all the objects of equipment which could be taken on a caving expedition; it totalled three closely-typed pages of foolscap. By and large the material consists of the same objects which the ordinary tourist needs, and here I shall only mention a few special items of caving equipment.

To begin with, clothing. Movement in narrow tunnels, where in many cases the walls are jagged, calls for a particularly stout one-piece suit—one-piece because when the caver is crawling or worming his way in a recumbent position through a squeeze the coat rucks up under the arms whenever the feet move forward and in the more usual head first progress you can lose your trousers. Since the stoutest material will tear if it gets caught on a jagged rock or the tip of some button calcite, you will never find a pair of overalls which have been used in caves that are not darned, and most of them are patched to such an extent that the original colour can no longer be recognized.

It goes without saying that the speleologist needs very stout shoes: the best have thick reinforced uppers, and for dry caves crêpe soles are best.

### *Methods and Equipment*

As to headgear, I have never seen two cavers who wore the same kind of cap. Professional speleologists know each other by their hats even when their faces are filthy, unshaven or covered with clay. It is surprising what monstrosities appear—hats with the brims cut off, berets with chin straps, old women's hats, scarves and tin helmets. Alois Hach's bearskin cap was famous; an explorer from the Harz, Norbert Zernig, wore a seaman's oilskin cap; and Dr. Hubert Trimmel, one of the best-known Austrian cavers, a yellow cap several sizes too large for him so that he could pull it right down on his neck when it was cold. Each caver follows his own inclination, basing his choice on fad or experience.

The same cannot be said for the wire or nylon ladder which is, on occasions, vital equipment in negotiating steep pitches.

Wire ladders naturally entail a heavy load for the speleologist, as they are carried on the back in rolls of about 30 feet, as far as the pitches where they will be used. Headers enable them to be belayed to a spur of rock or secured to a piton and then rolled out over the chasm; the lengths can be linked together producing, if necessary a 100-foot ladder. It is naturally more difficult when there is an upward pitch, for then there is no alternative but for one man to climb with the ladder on a pulley and belay it above so that the other members of the party can follow. If it is necessary to carry the ladder forward from an upper pitch so as to use it on another lower down, then a pulley must be left belayed above the first pitch and a double length of life-line through the pulley left hanging down. On the return journey one man is hauled up on the pulley line, and he belays the ladder, so that the rest can follow up it.

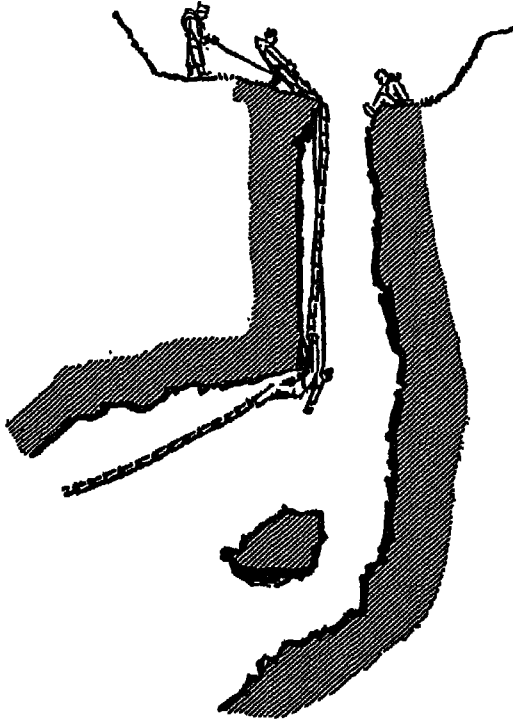
To the west of Heiligenkreuz, not far from Vienna, lies the Bodenberg, a squat hill about 650 feet high. On cold days, wreaths of mist rise at two places towards the summit; on closer inspection two dolines will be found about 160 yards apart: the entrances to the Bodenberg Potholes.

On one occasion, as we worked our way up through the thick scrub we were afraid that the snow would already have filled the two holes, but we soon saw that the warm wind, which comes in gusts out of the depths like the breath of a

### *Wilderness Under the Earth*

greedy beast had melted the snow around them. We put on our overalls and secured the ladders to a tree.

It was bitterly cold. I should have liked to descend at once into the warm vitals of the earth, but it was my first attempt on a wire ladder and I was obliged to let someone more experienced go down first. After a while, a muffled cry came from below telling me to follow. Not until Sigmund Heidrich of



Vienna, an old hand at caving, held me on the life-line was I allowed to set foot to the first rung of the ladder and climb down.

It was ridiculously easy for the first few feet, but gradually the daylight faded and I was left with only the light of my acetylene lamp. A rope had been securely tied round my chest . . . it paid out slowly. An upward glance and now only a faint greyness betrayed the opening. I descended step by step,

### *Methods and Equipment*

feeling with my foot for the next rung, until I acquired a sense of height and my progress was faster and less shaky, but suddenly I could not reach the next rung. Cautiously I lowered my lamp: the wall which so far had fallen vertically now receded sharply, following the roof of a deeper lying chamber. The snag was that the ladder was taut over the corner and continued with a slight fall away under the roof. There was nothing for it. I had to lower my hands a little to be able to stretch my legs round the angle; I managed to reach the next rung but the whole weight of my body was on my arms. I had to get further down as quickly as possible. Soon my feet were on the rungs and my backside over the corner, but then I was unlucky for the rope to which I was still attached jammed itself tight against the corner so that I could hardly pull it away. I was left in an unpleasant position on the ladder with only my hands and feet on the rungs, my body hanging down in a tight arc like a monkey performing antics in a zoo. I did not feel in the least playful. Feverishly I tried to free myself by bending my body and tugging on the rope. It gave a little but it was not yet loose enough to pull towards me. My ill-luck continued. The ladder swayed, I slipped my feet out of the rungs only to feel a sudden pain in my arm: the acetylene flame was too near my armpit and had already burnt a hole in my overalls. My skin was singed but at that moment I felt the ground under my feet. I could hardly let go of the ladder. A moment to recover my breath, and things looked brighter. From my position—I was standing on a large boulder that had become wedged between the two walls—I removed the lamp out of harm's way, tugged the rope, fished the ladder toward me and loosened it a trifle. Now I was ready to continue my descent.

This was my first acquaintance with a wire ladder. Since then it has proved a trusty friend—perhaps because it did not show me its best side at our first meeting and I always treated it with a certain amount of respect in the future.

Two different situations can arise in ladderwork. Firstly: the wall falls from a slight incline to vertical, in which case the ladder hugs the rock. The difficulty here is to use the rungs well and not to confine yourself to the tips of your toes. After a

### *Wilderness Under the Earth*

certain amount of practice, you get used to lifting the ladder below you from the rock with a foot in the rung so that you can get a good purchase with the other. When the ladder lies flush with the wall there is always a danger of which you must be constantly aware: should one of the rungs inadvertently get caught up on a projecting rock, then the whole lower part of the ladder will hang from it. On your further descent, the rung in question very easily slips from its rocky hook, suddenly releasing the ladder, the short slide is sufficient to scrape the fingers of the climber to the bone and then, if you are not using the life-line on the ladder—and this is sometimes unavoidable—it needs a considerable amount of self-control not to let go of the rung.

When the ladder hangs down free—the second possibility—this danger is not so great. Naturally, there will be a jolt when, higher up in the part of the shaft which is not overhanging, a caught rung comes loose, but the strength of the fingers and the hands are usually sufficient to take this strain. On the other hand, the amount of effort used on a free-hanging ladder is greater, since the lower part on which the feet should be placed bends forward so that nearly all the weight of the body is held on the arms. Anyone who has climbed a rope ladder knows this. The easiest way to climb is not to grasp the rungs as on an ordinary ladder away from the body, but to place the arms round the ladder and clutch it to the body with the fingers. Experienced cavers can climb with bent knees holding the ladder away from them, and in this way ascend or descend very fast.

Wire ladders should only be used when it is really essential, on account of their weight. If it is at all possible, free climbing must be the order of the day or a length of wire can be flung across a chasm to be used as a hold. The various rope techniques which are the common practice in mountaineering are never used in caving. On important caving expeditions life-lining has proved its worth: a karabiner is fastened on the chest to which the life-line can be attached, and in this way the caver is spared the tedious belaying and unbelaying at each dangerous spot.

Piton technique, on the contrary, plays a very minor role in speleology, and is only used to secure the life-line or the ladders.

### *Methods and Equipment*

There is usually so little purchase in the rock that it is advisable to bore holes with a hammer and chisel into which Rawlbolts with a hole in the cylinder-shaped heads can be driven: this is the only really safe belay on calcite wallstone.

A couple of sundries should be included in the equipment—trifles, the importance of which only becomes apparent when they are lacking—a compass and chalk.

A great deal has been written about getting lost in caves. In practice, however, it is the only danger in caves against which every precaution can be taken. The story of Ariadne's ball of thread, by the aid of which Theseus found his way out of the Labyrinth, is well known, but has no practical significance. That you can make a mistake, despite the thread, is shown by an experience that happened to me as a tyro in the Kohlerhöhle at Erlaufboden in Lower Austria.

Emerging from the right passage, I had just reached the entrance section of the cave. To the left a rubble slope led downwards, and I wanted to take a quick look at this unfamiliar place. Since I was alone, I tied, as a precaution, one end of a ball of string to a boulder and slid rather than proceeded in the normal way down the incline. The roof gradually lowered, the narrow tunnel seemed to continue in endless bends to left and right. The roof grew lower still, so I had to sit down and hop along on my buttocks with my line growing ever tighter in my hand. At last I had to lie down. Stones began to roll when I touched them. Overhead I noticed a patch on the roof covered with a white formation, while a few more white patches gleamed away to the right. I squirmed sideways to have a closer look; yes, more formations—small pure-white cones. Further ahead to my right they grew thicker and the white patches extended until they covered the entire roof. I felt like a hunter in pursuit of his quarry. Clutching my ball of string, I forced my way, now face down, now on my back, into the squeeze. The formations grew more fragile and crystal needles glittered superbly in the light of my lamp.

At last I decided to turn back. The line was still tight and stretched upwards. I started to climb, but after a couple of yards I could go no further; at the spot where the rope emerged

## *Wilderness Under the Earth*

from between the rubble and the roof there was only about 2 inches. I tried sideways—again without success—so I retired. But here, too, it was terrifyingly narrow. I could no longer lift my head and I appeared to be wedged in a stone trap. The jagged stones hurt my knees, chest and belly. Feverishly I began to scoop away the rubble. Soon a little more air came through, but now that the piles of rubble around me were still higher and my hollow was enclosed on all sides, of what use was my line? I knew more or less in which direction the exit lay, but I could go no further. As I crawled crab-wise through the narrow tunnel I had made the line still tighter. Now it could not show me the way out. After a short period of reflection, I felt better; my situation was not nearly as bad as it looked. Since I had crawled to the right, I must now return to the left. In this way I should certainly reach the spot down which I had slid. I began to sweep away the stones to the left, throwing them behind me like a mole, and edging forward a few inches at a time. A quarter of an hour passed. After another ten minutes the floor sank a little and I could advance without difficulty. At last I could stand up . . . a few more steps and I was in the antechamber.

Ever since that experience I have left my ball of string at home and used the method which speleologists have adopted after many years' study: it has proved advantageous on entering an unknown cave to start by drawing a sketch, for in this way you are not only sure of finding your way out comfortably but, by the very fact of sketching, you are forced to examine every chamber in detail. In addition to this, you spot many things you would have missed in a hasty advance and, at the same time, you are given a magnificent number of landmarks. A compass should naturally be used when making a sketch, otherwise the work is pointless: after a few bends in a passage, a man with the best sense of direction could not tell you whether he was going north or south.

This is a very safe method, but it wastes a great deal of time. In larger systems, which should only be explored by experienced cavers, it is an additional help to use direction marks. I personally draw an angle in red chalk at some prominent spot, making the apex point to the interior of the cave. Others

### *Methods and Equipment*

build cairns (although in larger chambers these can easily be overlooked), or make patches of soot by holding the acetylene flame close to the rock.

With many speleologists it is such a matter of routine that they can find their way back along a stretch they have covered with neither markers nor plan. What that means can only be appreciated by someone who has been in an enclosed cave and seen with his own eyes that each part of it looks quite different when seen from a different angle, so the experienced speleologist can always be recognized because he frequently lights up his rear for a moment to take note of the other view. Should all else fail, there is always the possibility of looking for your own footprints and following them back. In unfrequented stretches you nearly always leave some tracks and there are usually plans for those caves that are often visited from which tracings can be made beforehand.

While precautions can be taken against the danger of getting lost, there are other hazards which are not so easy to guard against: flooding, a fall or becoming a straggler.

Flooding, as the result of bad weather, is the most common natural phenomenon which can cause disasters. Most of the fatal accidents can be attributed to this, from the flooding of the Lur Grotto in 1894 which caused a great stir in Austria, to the tragedy in the underground watercourse of the Creuse in which six men lost their lives a few years after the end of the Second World War.

When caving at relatively high altitudes, very extensive water-formed caves or those that contain narrow tunnels should only be visited in winter when there is no fear of thunderstorms, for in actual fact the months of January and February are the driest in the year, because the rainfall is in the form of snow which remains lying above ground. This holds good in particular when there are sumps, which are passages filled to the roof with still water that occasionally dry up in the winter. Winter, then, is the correct time for exploring them; however, most sumps are impassable obstacles, for the only way of getting through would be to dive. As a result, particularly in our latitude and high above sea level, they can seldom be tackled because not everyone can stand a bath in icy water if



## *Wilderness Under the Earth*

he has no chance of drying himself later. There have, of course, been a few stout fellows who have not been deterred even by this!

A second source of danger which has been greatly exaggerated is rock collapse. This plays a far greater role in mining, for in that case artificial assaults are made on the mountain mass, sometimes causing an unstable condition, upsetting a balance which had taken centuries to achieve. The results of this disturbance of the natural pressure may cause slabs to split off from roof and walls until an arch is formed which can bear the burden above, or may lead to compensatory phenomena, such as rock fracture or the collapse of a gallery.

The conditions ruling in natural caves are quite different. We know all too little of the early development of caves, but one thing is certain; it took place so slowly that changes were always directed towards the maintenance of stability. Later the cross-sections, which were self-created, conformed best to the stresses in the rock, so that serious collapse need not be considered. As a matter of fact, in bombing attacks from the air caves are the safest places in the world, as America has established after systematic research.

It is obviously wrong to say that there is no danger of a cave collapsing. To begin with, there are the so-called lines of disturbance, portions of the rock which have been torn apart by some tectonic influence. In certain places one finds boulder slopes, roofs which are only partially joined to the rock above, and boulders standing on end or wedged in between the walls which the slightest touch can cause to fall. But these are not genuine collapses, but merely the end-process of conditions caused originally perhaps thousands of years ago by a landslide. Alfred Koppenwallner, the discoverer of the Tantalhöhle, can testify that pieces of falling rock have to be reckoned with; out of—as one might say—a clear sky, a boulder fell at his side missing him by inches. Or, again, my friend and caving comrade, Ivan Gams of Ljubljana, received a serious head injury from a stray falling rock.

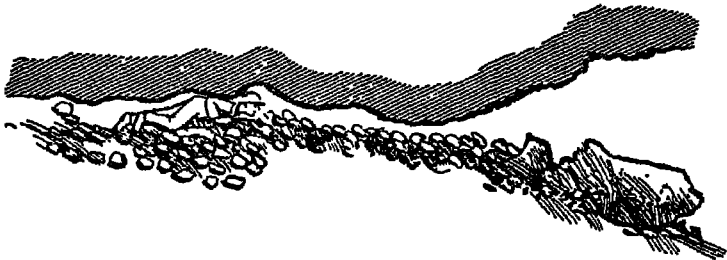
Far more frequent are collapses in those parts of the cave nearest to the entrance where external weathering comes into force. Water percolates into all the cracks and joints, and,

### *Methods and Equipment*

when it freezes, exerts an enormous pressure, slowly and remorselessly destroying threshold regions of caves. Examples of this are the many caves that have huge entrances and antechambers from which lead only a few miserable tunnels; these have been formed by weathering as the piles of debris on the floor prove. In parts of caves accessible to the frost, the caver has to be particularly careful when climbing.

Naturally, it is a question of the nature of the limestone, some of which weathers so easily that at the mere touch on a wall a veritable avalanche is caused. Dr. Hubert Trimmel, when attempting one day to enter a cave entrance near Weiz in Styria, was literally buried by stones and rubble, and was very lucky to be able to extricate himself.

Yet another hazard for the speleologist is getting stuck in narrow passages, a possibility which, at first sight, seems rather



comical but is far more serious than one would imagine. Forcing your body through narrow fissures or crawling on all-fours is one of the disadvantages of caving. The actual danger only begins in the "squeeze", as speleologists call those narrow places which can only be negotiated by lying on your stomach and in which there is no possibility of turning round. There is plenty of rock climbing above ground but "squeezes" exist only in caves. It is a particularly uncomfortable sensation for the novice when he enters one of these passages which tapers and narrows until finally above, below and on each side of him the bare rock touches his body and he has to force his head and shoulders through. His outstretched arms can no longer be brought back to his sides and the only means of advance is a

## *Wilderness Under the Earth*

swimming-like manoeuvre on the ground, a progress with the arms and hands not unlike the "crawl". His lamp is placed on the ground and he is obliged to work a few inches forward and push it along in front of him. In these squeezes the heart-beats sound like the dull rumble of thunder.

Just as there are expert climbers, there are experts in this crawling. One might imagine that here the constitution would play the most important part, and this is to a certain extent true, since fat men are not particularly suited to this sport, but it is far more a question of skill and lighthness, for a squeeze must not always be considered as a horizontal passage. On the contrary, many narrow tubes seem to take a malicious pleasure in weaving in all possible directions, sometimes like a corkscrew, so that the caver has to turn over in them, like a borer, on his own axis.

Many squeezes have the reputation of being testing grounds for cave-crawlers. This applies to the "S-bend" and the "sharp angle crawl" in Hermann's Cave and the "Crocodile" squeeze in the Dachstein Mammoth cave. The following delightful story is told of a squeeze which joins the old part of Hermann's Cave in Lower Austria to the recently discovered Kyrle labyrinth.

Erika Trimmel (at that time Erika Weber) was to be pushed one day through this narrow passage. Hubert Trimmel crawled on ahead, followed by Erika with the third member of the party, "Mauri" Mrkos, bringing up the rear. Hubert had just passed the narrowest part of the squeeze and had arrived in a chamber when he noticed that Erika was no longer behind him. He turned round and crawled back, to find that she had forced the upper part of her body through the narrowest portion, but could not get her hips through. Hubert cheerfully caught Erika by the hands and tried to pull her through but he did not know that Mauri was also trying to free her by pulling on her legs with all his might. The two men were apparently of equal strength. In blissful ignorance, both of them went on tugging, according to the legend, for about half an hour, but I think we can take this part of the story with a grain of salt.

Nevertheless, some very unpleasant situations have arisen in

### *Methods and Equipment*

squeezes. There is a tube in the Lur Grotto into which a boy once penetrated and, according to him, discovered a fine stalactite chamber. An adult tried to repeat his performance, with the result that at the very outset he got hopelessly stuck, and all attempts to pull him out failed. Finally, he lost consciousness and nothing remained except to send for the dynamite squad and blow him out. Fortunately, this proved successful. Squeezes, whose destinations are known, need not be feared to the same extent as those which are unknown or are being explored for the first time. In my youth I often came off scot free from situations, the gravity of which I only realize fully to-day.

With Alois Hach and Hans Gabler I stood one day in the main chamber of "The Spider Hole" at Kirchberg on the Wechsel. We were disappointed. The entire cave consisted of this modest hall with a cul-de-sac extension at the back and a short passage to the exit. Hans lit up every corner trying to discover some continuation, and what he found did not look very promising: it was the beginning of a squeeze which might be just possible. I crawled on ahead followed by Hans. For a few yards it continued at the same width; then came a slight narrowing, through which I could not squeeze. So I retired, took off my pullover and shirt, leaving the damp overall next to my skin. Back once more into the narrow part. . . . I wriggled and squirmed . . . and I was through.

After another couple of yards I came to a second obstacle—a corner. I doubled myself down and it was not too difficult to get through, but after a couple of feet came another corner in the opposite direction. With my hips still in the first bend, I had to wriggle the upper part of my body over to the other side to get deeper. My feet hung in the air; I pressed them against the wall to get some purchase, stretched a little and made some progress. As I was working forward I suddenly wondered: How on earth shall I get back? I tried to wriggle backwards, but that was impossible, for only by using my feet had I been able to get as far as this. I must go forwards, now no longer with the object of exploring some unknown region, but simply to be able to turn back. Remembering my comrade I shouted over my shoulder.

## *Wilderness Under the Earth*

"I'm still in the first squeeze," he replied. "Does it go further?"

"Yes," I shouted. And it certainly did. I had passed the S-bend, but now the passage narrowed again. Then came a slight broadening—I lit the way ahead—and saw that it dwindled to a hole only 2 inches wide.

The sweat ran down my forehead and made my eyes smart, but I took little notice of it as I was too intent on getting out of my present predicament. Was I to remain stuck here a few yards from the hall and my companions, and not many more yards from the busy road outside the entrance? My muscles began to hurt from the unaccustomed arm position. How should I free myself if the pain got any worse? I dared not remain there inactive and tried to think the problem out with a cool head. Two yards in front of me the passage broadened a little. I must succeed in turning round as I had no chance of working my way out of here, except head first.

At last I reached the broader passage. I tried to sit up, but found that this was out of the question.

Already slightly calmer, I looked round. Here at least I could take a deep breath, which hitherto had been impossible. A pointed stone dug into my chest. I pushed it forward and more rubble lay beneath it. I swept it on ahead of me and had more play. I could now use my arms comfortably, but there was no possibility of turning round. For a few seconds I lay there motionless. I heard my companions calling, but I was too tired to answer. Once more I raised my head, which I had laid on my arm . . . my throat muscle were quivering. To my right I spotted a cleft as big as an arm. Was this, perhaps, my salvation? I stuck my right arm up to the elbow in the cleft, compressed myself more and more like a "boneless wonder" . . . once more without success.

I made a second attempt. Turning over on my back, I stuck my left arm in the cleft, lifted my legs with the knees bent and rolled myself into a ball. My muscles would hardly function and I pressed my shoes against a bare patch of rock. Not an inch would it give! Now my feet were already above my head. Using my arm in the cleft as a pivot, I turned a half-somersault. Now I was lying, somewhat distressed, on my

## *Methods and Equipment*

stomach; my chest hurt as a result of being doubled up, but I suddenly realized that I had succeeded and that now I could make my way back unhindered.

My confidence, however, was premature: there was, of course, the double bend. I pondered for a long time as to what was the best way of negotiating this and finally decided to do it on my back. It was fairly successful; I had to struggle like a maniac, but I gradually progressed backwards. Now my head was already in the last part of the squeeze, which led in a straight line to the exit. I had just breathed a sigh of relief when, suddenly, my left foot refused to function; I strained all the muscles, but it refused to budge an inch. I felt with my right foot to discover what sort of an obstacle had been put in my way at the last moment and discovered that the water had burrowed out a shallow 4-inch groove in the floor of the tube, the rims of which rose at a slight angle. I had caught my foot in this groove and the sole of my shoe had stuck under the overhanging lip. I wriggled my body slightly backwards, but it was no good; my shoe was firmly trapped. If only I could have reached it with my hands, I could have untied the laces and slipped it off. But this was an impossibility in this S-bend: my arms were stretched forward and I could not even bring them back to my sides.

Hans and Ali had heard the familiar noise of someone moving about in a squeeze, and now they could hear me panting.

"Are you coming back?" they cried.

"Yes, I am," I growled between clenched teeth.

In my rage I tore at my trapped shoe, turning my ankle over until I thought it would break. I dug my feet in firmly and stretched. I heard my overalls tear as I grew more and more furious. Was the shoe giving? Suddenly I felt a heavy blow on my knee and I was free, but I was so tired that I lay there for some time motionless before tackling the last bend.

I made slow progress, but now the squeeze seemed quite roomy and I, too, was feeling better. The terror of the past few moments vanished, and when I crawled out at last and stood up I was able to summon up a smile.

Since then I have been slightly more prudent. I now know

## *Wilderness Under the Earth*

the dangers. But when I find a narrow passage through which a draught of cool air blows, showing that it is not an impasse and may house unsuspected natural treasures, the hunting fever still takes hold of me. My heart begins to beat faster, and things have to look very grim before I reluctantly abandon the attempt.

\*            \*            \*            \*            \*

I have now dealt with the three commonest elements of danger, from which it is clear that they can frequently be surmounted if the caver has a clear head, plenty of common sense and a little luck. There is, however, one rule worth mentioning, and I purposely say rule and not commandment, for it cannot always be obeyed. It reads: *Never go into caves alone*. The reason for this is obvious; even in everyday life, on a pavement, on the stairs, or in a room, you can fall and lie there with a broken leg until help arrives. How much worse then must such accidents be in difficult, dark, underground regions? Furthermore, there is not very much chance that any one will come along unexpectedly. And then there is always the question as to whether the man who has had an accident can be rescued. How can you bring him back with broken bones through a squeeze? In mountaineering there is always the possibility of lowering the injured man down on a rope.

Nor does it always have to be an injury that bars the return to the lone caver.

On one occasion I was exploring the caves of Upper Franconia with my guide, Willi Zaunick. During the day we had visited the Förstershöhle at Waischenfeld in the Jura and that evening I had an important engagement in Muggendorf, a few miles away. Zaunick intended to complete his plan of the cave and would join me in due course.

Next morning he was still missing. I set out to see what had happened to him and met him turning the corner into the main square of Muggendorf, a few yards from his cottage. What had happened?

Shortly after I had left, he started to descend a narrow chimney. As he disappeared into it, he heard a dull thud overhead and noticed that a round boulder about 2 feet in diameter,

### *Methods and Equipment*

which he had carefully pushed to one side, had rolled over the opening and closed his egress. When every attempt to raise the heavy boulder had proved fruitless, Zaunick remembered his climbing hammer. He had remained in the chimney until six o'clock the following morning hammering away one splinter after another from the boulder, until it was light enough for him to push it aside.

Now, even had Willi Zaunick forgotten his hammer I should have eventually rescued him, but this example shows that the chance of having unpleasant accidents is a continual hazard for the caver. Furthermore, if the same mishap had happened to a lone explorer who had no means of freeing himself the story would have ended quite differently.

*The dangers one already knows are already half overcome;* in time and with experience one learns how to cope with them. Far worse are those incidents which happen just at the moment when you do not expect them. But here, too, the right equipment can work wonders. Besides, when everything else fails, you have always got a friend who will get you out of a tricky situation, with an outstretched hand, and who, if necessary, will risk his life for you. Scientific discoveries, exploring luck, marvels of the subterranean regions—these may remain as unforgettable memories, but I must also mention the comradeship, the complete selflessness, of speleologists is one of the finest features of caving.



## *Chapter Four*

### EXPEDITION TO THE TOTES GEBIRGE

THE MOST EXTENSIVE, barren and at the same time deserted limestone region in Austria is the Totes Gebirge, flanked on the east by Aussee district. Mountaineers who like difficult tours arrange to meet up on the Dachstein beyond the Aussee basin, but on the whole people seldom remember the Totes Gebirge except in winter, when the bare slopes attract skiers, although even then only a few experts venture into this lonely terrain.

In March, 1948, a short notice appeared in the newspapers: "The skier Hubert Jungbauer from Linz, on a tour over the Trageln on the south-east border of the Totes Gebirge, fell to his death into a pothole. His body could not be recovered." I paid little attention to it, and it was not until the spring of 1951 that I heard it mentioned again, for then I received an invitation from the Styrian Caving Group to take part in an expedition to the pothole on the Tragelhal, the scene of the tragedy.

17.8.1951. After an interminable journey by train, I arrived at Tauplitz-Klachau and looked around me for some signs of the great event of that summer, the Tauplitz Expedition. I saw only a middle-aged man carrying, like myself, a capacious rucksack. Turning to him, I asked the way to the Tauplitzalm.

"Are you joining the expedition? We've got a pretty stiff climb. The Alm with its two small lakes lies over there behind that ridge." He pointed to the mountain in front.

I knew that he was a native by his dialect, so I took the opportunity of learning more about the Linz skier's death and at the same time about the terrain.

"I belong to the Mountain Rescue Service in Admont," said my fellow traveller. "I was up there with the first team.

### *Expedition to the Totes Gebirge*

Even to-day we cannot account for the accident. Jungbauer was a very experienced skier who knew the descent over the Trageln and also the existence of the potholes. As he passed them on the climb up, he said to his companion with a shrug of his shoulders, 'Well, if anyone fell into that . . .'

"On the descent, skiers usually stick to a given track. No one knows why Jungbauer made a detour into a hollow and up a further slope, only to shoot down towards the opening of the pothole into which he fell. A broken ski in the snow near the edge of the abyss proved that he was still making desperate attempts to check his headlong descent.

"His companion immediately notified the hut-keeper on the Tauplitzalm and the Mountain Rescue Service. We lowered one of our men, the twenty-year-old Burghofer, on a rope into the shaft. At 130 feet, he landed on a snow bridge and called up that he had seen blood on the snow. We lowered him down slowly to nearly 600 feet. Here he came to a halt on a platform and noticed further patches of blood. He told us that the shaft continued much deeper and split up into five or six branches. The unfortunate man must have fallen into one of these and it was impossible to tell which. As we had not sufficient length of rope to lower him any further, we abandoned our rescue attempt. Of course, there could have been no rescue, for no one could have been alive after a fall like that."

Moved by the memory of this tragic story, he was silent for a while. Our path climbed in easy bends through the pine woods.

"In the winter, this is the ski descent," he suddenly remarked.

"What! Down this uneven, winding path?" I said with surprise.

The man laughed. "You can't see anything of that in the winter, nor the trees and the telegraph poles. Twenty to twenty-three feet of snow is no exception here."

After a three hours' climb we reached the ridge of the Tauplitzalm. The path petered out into a tangle of tracks; the trees were less frequent; brown and white cattle grazed on the sparse, spicy-smelling grass. We turned to the right towards the Graz Hut, which served as a base for the expedition.

Here there was more evidence of the expedition's activities.

## *Wilderness Under the Earth*

Rolls of wire ladder lay piled near the door, together with bulging sacks, field telephones, climbing ropes, canvas sheets, and everything needed for mountaineering, camping or caving. From time to time a number of French boys appeared, hastily grabbed a bundle and disappeared up the mountainside. I looked round for some acquaintance who could explain to me in German how things stood. At this moment a well-built, grey haired man came on to the hut balcony. He spoke a few words to the boys in French, and they started to cover the equipment with waterproof sheets. Another Frenchman, I imagined.

No, I knew that face somewhere from photographs. The elderly man was none other than Hermann Bock, the explorer of the Lur Grotto and the Dachstein caves, the doyen of Austrian caving and, at the same time, the head of this expedition. I went up and introduced myself, asking whether I could be of service to him.

"We're just knocking off for to-day," he replied, taking me into the living-room. "We've already been working for three days and most of the equipment is now lying up there near the shakehole. We shall finish to-morrow, and the following day we shall begin the descents."

The room gradually filled up. The boys, whom I discovered were Boy Scouts who had come to the mountains for a few days and had volunteered to help with the transport, sat down to plates of steaming soup. The cavers drifted in. I greeted Karl Wiesler, the cave-guide from Peggau, who introduced me to the second-in-command of the expedition—the head of the Styrian Group—Johann Gangl, and his wife who accompanied him on all his caving trips. This was my first meeting with Norbert Zernig, who is considered one of the toughest and most daring potholers among the younger generation, and finally Hubert and Erika Trimmel. This was the only evening when we could all foregather in a convivial party—one of those rare opportunities when enthusiastic speleologists from all parts of the country have an opportunity of reviving old memories, telling their experiences, and making plans.

*18.8.51.* It was a two-hours' climb from the Tauplitzalm to the Tragelhal. Trageln is the name of the southernmost spur

### *Expedition to the Totes Gebirge*

of the Totes Gebirge, situated between the two mountain streams, the Salza and the Grimming. It was particularly agreeable to wander through the pleasant meadows past sapphire-blue mountain lakes towards the boulder strewn desert of the Totes Gebirge. Erika, Hubert and I followed the yellow markers up to the plateau. At first it was an easy stroll through larch plantations with the sparkling Steyr Lake far below, but these soon gave place to rocky terrain and in places we had to scramble over boulders as high as a man. At last, the steepest part of the trip lay behind us, and we came to regular slopes, shelving high up the walls. There was no path here, merely the approximate direction marked by little cairns. Underfoot there was a constant cracking, as though we were treading on potsherds—though in fact they were rock flakes, the last vestiges of a bed which to-day has disappeared. Here and there were a few isolated clints of the old rocks in loose squares lying on the lower strata: the process of weathering on this ground which is unprotected by any trace of vegetation continues ruthlessly. Here also were grooves several feet deep caused by rain-water streaming down the rock slabs—a typical feature of Alpine limestone.

After a short rest, we pursued our climb. We put up a covey of snow partridges. The sun's rays were very powerful, but the east wind brought in its wake a tang of ice and snow to cool our burnt skins.

A final crest and there ahead of us lay the scene of the tragedy, the Tragelhal at the foot of the Leckkogel.

The host of weary and perspiring reporters who later climbed up here compared this region to a lunar landscape. This comparison involuntarily springs to mind each time one visits a limestone zone, for the bare rock is exposed with its myriad joints and crevices, and a network of cracks and fissures runs all over the surface.

Dotted here and there, like beasts removed from their normal surroundings, the tents had been erected in the dolines. Here, too, one was reminded of an outpost of earth-dwellers trying to get a foothold on some other planet. The movements of the men scurrying about in all directions were ant-like—undisciplined to outward appearances but all with the same goal in

## *Wilderness Under the Earth*

view. Everyone was so busy with his duties that our arrival passed almost unnoticed. Frau Gangl erected her kitchen tent; two field telephonists laid the last few yards of line connecting the Graz Hut with the advanced camp; Zernig scrambled up the rocks looking for a spot where water from the high-lying patches of snow was to be had in sufficient quantity, and Wiesler had taken on the responsible job of quartermaster and was giving a final check to the ropes and ladders to which we should be entrusting our lives. Finally, Gangl appeared at the doline with five men. They had undertaken an almost superhuman task—the transport of a 300-lb. winch, to speed up the ascents and descents in the pitches.

We delivered our loads of material to Wiesler and returned to the valley to bring up a second, so it was not until evening that we had a chance to take a thorough look at our surroundings. First we wandered as far as a small rocky mound on which, secured to the rock with wires, a cross had been erected in memory of the dead skier. I opened the metal box which contained a book recording the cause of the accident as well as the rescue attempts. Many visitors had entered their names in it, and it was touching to find the names of Jungbauer's widow and his two children.

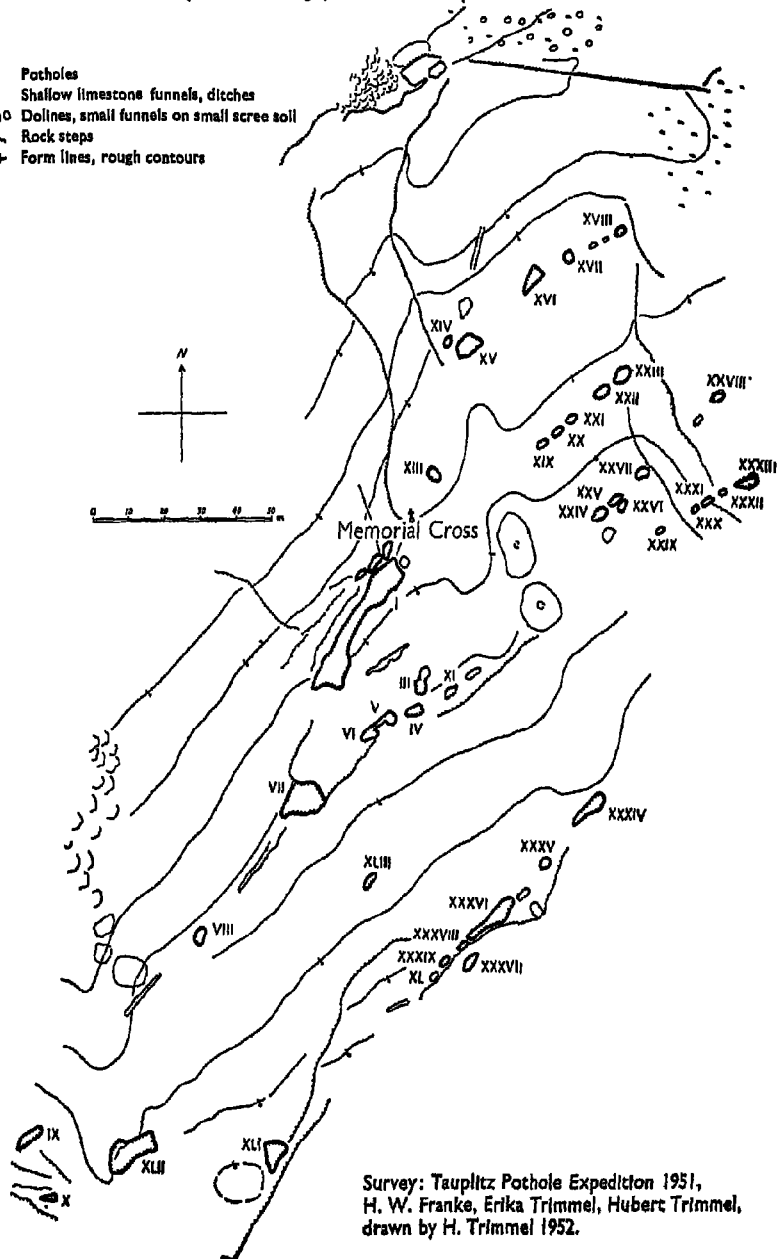
One of the aims of this expedition was to recover the corpse. Just below the rock with the crucifix was a broad shaft, stopped up with snow. Was this the one in question? Recently there had been some doubt, because after extensive searches, the Graz group had found other potholes in the immediate neighbourhood. In the memorial book was a photograph taken in winter of the fatal shaft: in the centre of some huge patches of snow yawned a black hole. Even the Mountain Rescue Service from Admont and the hut-keeper, Binder, were not quite certain whether it represented the shaft entrance below the cross.

19.8.51. To-day work at the pitches began. The weather was favourable, not a cloud in the sky. Everything was ready. In a group, we walked over to the big pothole to see the best way of tackling it. I clambered down a 20-foot narrow cleft, using chimney technique, to the bung of snow. Treading on it cautiously, I found a narrow passage free between the snow and the

# Plateau at the east foot of the Trageln

(Totes Gebirge) Sectional Map

- Potholes
- Shallow limestone funnels, ditches
- Dolines, small funnels on small scree soil
- Rock steps
- Form lines, rough contours



Survey: Tauplitz Pothole Expedition 1951,  
H. W. Franke, Erika Trimmel, Hubert Trimmel,  
drawn by H. Trimmel 1952.

## *Wilderness Under the Earth*

wall of the shaft, but it was far too restricted for anyone to get through. I looked around. Perhaps there was a side fissure free; this would save us the big job of exposing the entrance. In one corner of the shaft I spotted a tall narrow opening. . . . I went inside only to be swallowed up in the darkness. My eyes were still dazzled by the sunlit snow and it took me a long time to get accustomed to the dark, and then I could hardly believe my eyes. I was standing in a roomy chamber with a vaulted Gothic roof, while from the walls hung a host of sausages and sides of bacon. I quickly realized what had happened: our wives must have looked for a cold storage room to protect our provisions from the bright sun. They certainly could not have found a more suitable place than this ice cellar.

Looking up I spotted a new face. It was Franci Bar, a Yugoslavian caver and a well-known photographer of caves.

Gangl wanted to try and break through the snow cap into the big pothole. Dr. Trimmel, on the other hand, considered that the most important thing was to get an overall picture of the zone, and with Erika we began to make a survey. We proceeded systematically, working from the cross and plotting the position of every pothole. We explored the smaller ones immediately, since there were plenty of ladders at our disposal. Many of the pitches went only 60 to 100 feet deep while others descended into unplumbed depths. The latter we kept for later.

*20.8.51.* Our surveying continued. Although it was very boring, it gave us a magnificent picture of the plateau. It showed that most of the potholes were joined to a fault which runs through the high ground as far as the walls of the Leckkogel. Where they joined the latter we found a broad cleft in the mountain and decided to take a closer look at it. The main fault, however, continued and we could follow it far up the mountainside.

The other shafts, too, lay in clusters near the coombes adjacent to the fault. Very few of them could not be incorporated in this network.

By the time we had completed our task we had catalogued forty-three potholes close-set round the cross, and at least a

### *Expedition to the Totes Gebirge*

third of them certainly descended to a very great depth. To me the important thing was that the original plan of the expedition had come to grief, for despite several attempts at dynamiting, Gangl could not open up the main pothole, which we already knew was very deep. On the other hand, a sufficient number of other holes were there at our disposal, but no one knew which were stopped up half-way down or which really descended into the depths. "Really" meant down to the water level of the Steyr Lake or to a rock bed below the limestone where the vertical pitches must give place to horizontal channels.

All that remained, then, was to trust to our good luck and go from one pothole to the next. Next day a start was to be made, but I still had an unpleasant task to perform. The potholes had to be numbered. Armed with coloured paint and a brush I went from shaft to shaft and, lying on my belly and bending over the edge, I painted the Roman numbers from 1 to 43 on the walls. Where the edge of the shaft was too friable and there was a danger of my falling in, Erika held on to my legs. In gratitude I painted her toenails through her open sandals with the remains of my red paint! Hubert was furious. The others pulled his leg because his wife had appeared on a caving expedition with red lacquered nails.

21.8.51. The first descent into Pothole XIII began. Wiesler, Zernig and Lach formed the first group—a particularly commendable effort on the part of Lach who had lost all the toes of his right foot from frostbite during the war. They took with them a field telephone and Hubert was detailed to be in charge of the surface telephone. At the other end of the line was Norbert Zernig, who had often carried out surveys with Hubert. Their main idea was to try their hand at the difficult task of pothole surveying. Naturally it is very difficult for a man to sketch hanging on a ladder and plans of pitches are usually drawn later from memory, but on this occasion Norbert gave his observations over the telephone and Hubert drew them according to the details given.

Shortly after this a second group entered the shaft. Unfortunately that day I was on surface duty and had to content myself with following reports from Norbert.



## *Wilderness Under the Earth*

"130 feet, a scree slope interrupts the vertical pitch, temperature 2° C.

"380 feet. A flat ledge leads into a labyrinth of galleries. We are going in.

"A chamber, 130 feet long and 170 feet high explored. Floor covered with clay."

Not until evening did the men reappear. In the meantime the women had prepared a hot meal. Sausages and bacon stood on the table in the mess tent and the orderlies served everyone with oxtail soup. Cooking was done in the Graz Hut, and the hutkeeper Binder brought it up on his mule in a dixie to the foot of the rock face, from where the members of the expedition carried it on their backs.

22.8.51. The number 13 had brought us no luck. At 380 feet all the extensions were filled with rock fall and we did not succeed, as many of us had secretly hoped, in finding a communication with Pothole I which was presumed to be the scene of the accident. After this setback it seemed advisable to adopt another working method and Gangl detailed several groups to explore various shafts. Should one of the group find a hole of great promise, the rest could then concentrate all their efforts on it. The regular members of these groups were Gangl and Zernig, Lach and Wiesler, and Hubert Trimmel and myself. Although we set to work with great enthusiasm, no decisive progress was made that day.

23.8.51. The sixth day of the expedition. The worst of our sunburn had healed and we were as brown as gipsies. Our encampment, too, looked like a gipsy camp: large pots stood upside down on slabs of rock to dry; ragged caving overalls, drying in the sun, fluttered on lines strung from tent to tent; the kettle was on for tea.

After breakfast we put on our overalls and walked across the plateau carrying our rolls of ladder and lamps. Pothole XXVII was to be explored. It did not look particularly promising, for we could see the bottom. If we did not find a side-gallery it would be one more setback.

I secured the ladder to a small rock bridge and paid it out.

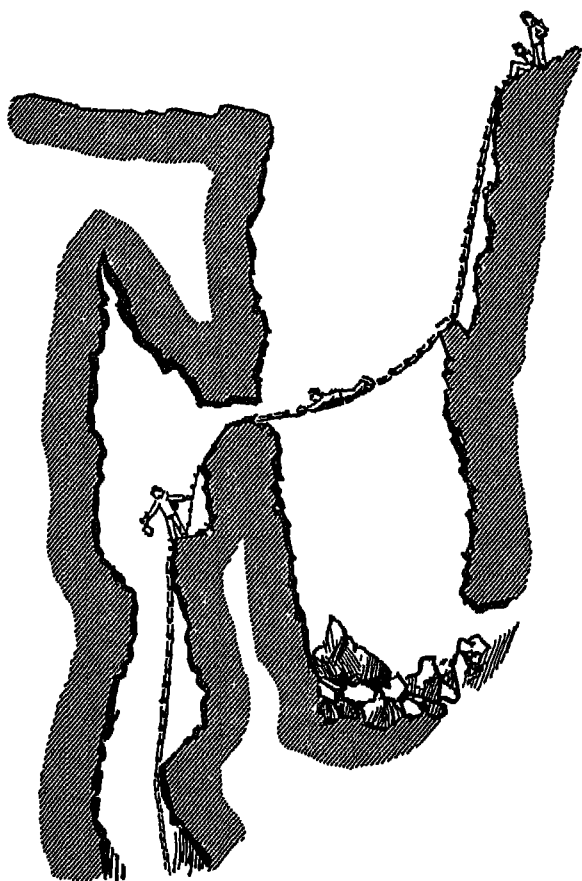
### *Expedition to the Totes Gebirge*

Hubert was the first to descend and as soon as he was down I followed. We were soon standing on the cap of snow which covered the floor of the shaft. Light filtered through a chink from the neighbouring shaft—we had already visited it and found it closed. I cast a glance upwards and saw Erika's sun-burnt face bending over the edge of the shaft; she waved to us but I was intrigued by something else. Thirty feet above us, I had spotted a small cleft in the wall face. Our ladder, however, was hanging down the opposite wall but a ledge ran from it to this hole. I climbed up the rocky face until I reached it. It was covered with algae and was as slippery as saddle soap. Holding the wire ladder firmly in one hand I took it across with me for safety. It was an unpleasant feeling—had I slipped I should have been hanging with one hand on the ladder, which would have swung like a pendulum. But nothing ventured nothing achieved, and I managed to reach the hole, let go the ladder, and crawl head first into the darkness. I could feel nothing except the rock at the opening: a good sign, for it showed that it must open out, but rather unpleasant for I was now floundering with my hands and feet in the blue, supported only by my belly which lay in the passage. I had to stand almost on my head to reach the rock below. Slowly I let myself slide deeper, dragging my feet behind me, and finally stood quite comfortable on an outjutting rock. My eyes now became accustomed to the darkness and I could see a deep pitch below me. I heard Hubert call me from outside. Turning round cautiously I looked out through my "window". Hubert had also reached the rock ledge and was preparing to climb higher. When he saw me he asked: "No way on, I suppose?"

"On the contrary," I replied. "Come and see for yourself."

Hubert took an easier way. He swung the end of the ladder over to me—I pulled it into the opening and belayed it round a spike of rock. Now we had a kind of hanging bridge—but of course, with no railings. Hubert lay flat on the ladder and crawled forward like a salamander. In this way he avoided the danger of the algae-covered ledge.

I had to make room for him and descended further down the ladder. Its end now hung free over the abyss but I could



distinguish a platform below me to the left. But however much I stretched I could not reach it, so I had to swing over on the ladder. I began to sway slowly and touched the edge of the projection . . . at the first swing . . . to and fro a couple of times and I dropped gently onto the edge of the abyss. A few stones crunched under foot. The ladder threatened to sweep me away on its return swing but I managed to hold my ground and to belay it, which was essential as otherwise my retreat would have been cut off. I pulled the end of the ladder into a cleft in the rock, and Hubert could now follow at his leisure.

We sat side by side on a heap of scree and listened to the

### *Expedition to the Totes Gebirge*

stones we threw down. We could hear them thundering down in the depths.

"We've not brought a long enough ladder to-day," said Hubert.

"I'll take another look at that side gallery," I replied, "and then we must go and fetch the ladders."

To the left of where I was sitting, a high but narrow fissure led southwards. After a few yards a boulder was wedged upright blocking the way, but there was just enough room to slip underneath it. I lay flat and wriggled through. The fissure continued in its original direction. I could now walk erect on the rubble floor. A dim light suddenly appeared ahead of me. I took another few steps and then saw it was the reflection from a block of ice—an incredibly mild light that seemed to radiate in slow waves out of the ice. I found an immediate explanation for this incomparable lighting effect: I had stumbled upon an adjacent shaft, the entrance to which was blocked by ice. The harsh light of the midday sun penetrated deep into the ice, transforming the hosts of air bubbles into this gentle gleam, and draughts of cold and warm air rippling along the surface of the ice caused the slight changes in the strength of the light. This is how I imagined the light at the bottom of the sea would look: I could have stared at it for ever.

At last I had to look away and return to Hubert, who was chiefly interested to know which shaft I had entered. While he climbed up, I worked my way through once more to the ice-blocked shaft—on one side there was a cleft open above—and called at regular intervals without receiving a reply.

After a while my throat was hoarse with shouting, and as I was dripping with sweat and standing in a cold draught which rushed down the cleft and into the depths of the ice shaft I decided to retrace my steps, and climbed up to the shaft window to talk to Erika, who was still sitting up aloft.

"Hubert's been running from one hole to the other, but he didn't hear you."

I gave her the exact direction in which Hubert should look and crawled back once more into the ice shaft. A few minutes

## *Wilderness Under the Earth*

later we were in communication. When I came to the surface, Hubert showed me the ice shaft from above.

"The odd thing about it," he said, "is that this pothole is only joined to our No. XXVII by a cleft below. It proves that Dr. Arnberger was right when he maintained that shakeholes can cause inner fractures like this."

24.8.51. My old friend Alois Hach appeared on the plateau and naturally he joined Hubert and myself in pothole XXVII. We were longing to get below. One after the other we made the trip across the ladder to the window—a balancing act of great difficulty for as soon as you were in the middle of the ladder it began to sway like a crazy pendulum and made you feel seasick, and, despite all his caution, Ali dropped the acetylene lamp I had lent him. I was, however, able to rescue it without much difficulty and found that it had suffered no damage except a bad dent.

Our point of departure that day was the storey below the window. There was an unpleasant passage to negotiate—a steep, narrow gutter into which the ladder continually slipped so far that it could hardly be reached by either hands or feet. While climbing the rock I had to pull the ladder away from the wall and this did great damage to my fingers and palms. The acetylene lamp hindered my hand movements and banged against the rock. Muffled cries came from above. Already below me I could see the next halting place—a narrowing of the shaft in which boulders were wedged. Far above I could see the swaying ladder. Hubert and Ali waited until they could lower the bundle of ladders; I looked for a firm handhold and called to them to let it go. It was now 130 feet below the surface.

I forced my way past the boulders and climbed another 30 feet down. A small chamber broadened out into a domed cavern and beneath it I could see the rock fragments on the roof apparently hanging in the air without any visible means of support.

This was as far as one could go, but perhaps there would be a continuation near the wedged boulders above.

I moved carefully with the ladder rolls which had now reached me over the boulder fall and wriggled further into the

### *Expedition to the Totes Gebirge*

main fissure where a narrow rift led downwards. My comrades joined me. It was cold down there,  $4.7^{\circ}$  C. according to the thermometer, and we could see our breath condensing by the light of the lamps. We belayed the wire tether to a column of rock and hung our ladder on it. Slowly it was unrolled and lowered into the chasm; by the weight we knew whether it hung free or had been caught up somewhere. It was hard work in the confined space above the pitch, and there was only room enough for one man to hold the ladder while the other sat in the boulder chamber. The lamp was secured to projecting rocks and threw gigantic shadows upwards. At last 200 feet of ladder was hanging down into the unknown depths. I was the first to descend. The fissure was very narrow and I had to force myself through, clutching tightly to the ladder. The sharp rocks tore holes in my overalls and my equipment satchel dragged as I forced my way down backwards. The rock face was jagged and the edges sharp as knives, so my knees and elbows were soon badly cut. The frost had fractured deep scars in the rock; loose stones gave way and fell with a thunderous roar into the darkness. At last the shaft broadened out with a kind of miniature bridge. I took a short rest and then continued my descent. . . . More narrows, the pothole was not quite vertical, but on a steep incline. If it got any narrower, it would probably prevent any further progress, but it was now time for us to go back so the problem was left unsolved that day.

25.8.51. Wiesler accompanied us because Ali had to leave. We reached the previous day's point of descent without incident, but when I went down a few feet lower to my surprise my legs felt no more rock. With my foot, I fished the ladder towards me and slipped the upper part of my body downwards. Holding the lamp with my left hand, with the black void dimly lighted, I now saw that I had climbed through a roof opening into a shaft-like chamber which differed considerably from the upper parts of the pothole, for it was very spacious, with a vertical pitch below, apparently bottomless. I was now 72 feet below the boulder fall, and climbed down a few more feet in order to reach a small ledge. I shouted the details up to

## *Wilderness Under the Earth*

my friends but they could not understand me, so I realized there was no point waiting where I was, as squatting on a narrow ledge is tiring when you have to huddle against the wall. A life-line would have been useful at this moment although it would have increased the danger of falling stones, for although Hubert and Wiesler climbed carefully, they sometimes dislodged stones which fell perilously near my head. When the warning cry came from above, "Look out, loose stone!" everyone secured his breast-line with a karabiner to the ladder to safeguard against a fall and drew his head in against the wall until the little avalanche was finished; then you could proceed. In places the ladder hung free and swayed to and fro while the walls alternately seemed close and far away. Wiesler and Hubert had long since reached the broad chamber and were climbing high above my head. I could see their lamps as trembling dots of light, an impressive sight. Step by step we proceeded, rung by rung, occasionally taking a short pause for breath at a ledge and then going down and down. . . .

Suddenly my foot was in the void at the end of the ladder but as luck would have it, here too was a small platform about two feet square. I waited for my two comrades to join me. Our voices echoed in the vaulting, and from time to time we heard the splash of water. We examined our surroundings. We were the first men ever to penetrate this corner of the earth's vitals. No beast or plant could live here, and yet we were among the remains of milliards of living creatures from prehistoric times—the mussels from whose shells the limestone had formed. While above the ground only cross-sections of their shells can be seen, down below, through the action of the water, they were etched out in relief. All the walls were covered with them and many strange forms were revealed in the light of our lamps. These particular walls were beautiful—yellow and white, glistening with damp and sometimes striped with red horizontal bands.

Further descent was impossible. The smooth limestone walls stretched downwards and we could see niche-like side vaults. We dropped a stone and Wiesler timed it with his stop watch: it was seven seconds before we heard a crash followed by a few

### *Expedition to the Totes Gebirge*

others; then the noise grew muffled and died away in the depths which yawned inky-black at our feet. Nature had put up the bar. We had insufficient equipment, but perhaps some other day we could go down even deeper and explore this region for the first time.

The impressive silence which had fallen upon us was broken by our preparations for the return climb. Hubert made a start, I followed and Wiesler brought up the rear. As we climbed we heard our friend from Peggau below us whistling cheerfully to himself.

When we reached the surface and came out into the blinding sunlight, it was like taking a warm bath. Our clothes had still preserved the low temperature of the underworld and now we could feel the dampness penetrating to our skin. Removing our torn and dirty rags, we sat down on a boulder and for a few minutes enjoyed in peace the pure air of the heights.

26.8.51. Gangl told us that he could not spare any more ladders but, on the contrary, that he needed ours, for his group had also found a pothole of unknown depth. With additional help we brought up the ladders and by the time we had pulled up the last roll from our pothole Gangl had long since disappeared with his companions down pothole XXXVIII.

Towards evening a stiff wind sprang up, heralding a change in the weather. Woollen jackets and pullovers were brought out and we began to feel anxious for the group down below. We could not communicate with them, since they had started their descent without installing a telephone line.

At eight o'clock there was a sudden cloud burst and a thunder storm. The rain pelted down and immediately drained away into the countless rifts, clefts and shafts. This is precisely what made us anxious, for the natural drainage paths were the open potholes like No. XXXVIII.

When the rain stopped about midnight we heard the first noises from below and an hour later the last man came up safe and sound.

"We reached 900 feet," said Gangl. "A sounding with a 330-foot line gave over 1,200 feet with no bottom. On our way



### *Wilderness Under the Earth*

up there was a sudden roar, and a waterfall, tearing away rocks the size of a man's head, rushed past us. By a bit of luck we were in a side pocket and could avoid the intrushing water by huddling close to the wall."

27.8.51. Hubert and I explored three horizontal caves which he had found not far from the path. We surveyed them and I took a few photos.

Finally, we made a closer inspection of the spot where the big fault joined the Leckkogel. Although I found a circuitous route by which we could reach a long platform inside the huge ravine, no end could be seen. We could not risk a descent over the ice which closed the entrance to the depths because we had no ice equipment with us; we made a note, however, of this ice crevice for a further visit.

That evening Hermann Bock returned from a stroll on the plateau with news. He would not give us any details, but promised to show us something on the following day.

28.8.51. The last day. It was a rather sad moment, but we were all full of expectation.

At six o'clock in the morning we struck camp. Bock led us for two hours across the highland until we reached the wall of the little Brieglerskogel, and here he climbed up a scree slope and told us to follow. Now we stood outside a huge cave entrance which had been screened from below by a pile of scree.

"I haven't been in far yet," said this experienced caver who, despite his age, seemed to be able to smell out a cave, "but I know that it's worthwhile." With a smile, he bent down and picked up a brownish object which, on closer inspection, we saw to be a bear bone.

"We shall find more," he assured us.

We hurried inside. A roomy corridor bore slightly to the left and opened out into a large chamber.

"Careful!" warned Hermann Bock. "Don't tread on the patches of sand." We lit up the floor, and to our amazement saw it was covered with bear bones—ribs, pelvises and thigh bones, teeth and claws protruding from the sand. Wherever the eye fell there was nothing but bones of cave bears.

### *Expedition to the Totes Gebirge*

Unfortunately we had little time to explore the cave's many vast extensions but undoubtedly it was one of the most valuable discoveries of recent years.

Below the entrance I spotted a 25-foot wide and at least 1 foot 6 inches high lamellar structure in the rock. Something attracted me to it, I crawled inside, and another cave had been discovered. I christened it the Little Brieglerskogel Cave. After a round tour I found the entrance to a circular chamber and crept through a squeeze into it and stood up. The light poured in from above. A short scramble and I came out through a second entrance on the upper edge of a hummock into the fresh air once more.

While the rest of the party went on ahead, I lagged behind with Hermann Bock, who had made this remarkable find. This tough explorer, who will not allow anybody to carry his tent up to the heights, is one of the most outstanding personalities among Central European speleologists. A man of great culture and wide experience combined with good nature—a rare phenomenon in our day and age.

## *Chapter Five*

### THE ORIGIN AND DEVELOPMENT OF CAVES

OUR EARTH IS 6,000 million years old. Prior to this span of time, almost inconceivable to the human mind, it moved through the empty spaces of the Universe as a glowing fluid ball which was moulded into an oblate spheroid by forces due to gravity and rotation. As the result of continual radiation into space of immense quantities of energy from this hot mass, the earth's surface cooled, and was slowly changed into a plastic and, finally, into a solid state. Thus the earth acquired a gradually thickening crust. The preliminary stages of the solidification, the gradual growth of this crust of cinders from the furnace at the core, did not take place in a regular manner because too many forces were involved. The great drop in temperature between the interior and the exterior created stresses which could only be relieved by abrupt rifts and explosions—tremendous natural catastrophes, of which the earthquakes of to-day are but a pale reflection. Once the outer crust had formed, and was adjusted to the volume of the liquid interior of the earth, the process of consolidation continued inwards, but once again the change from liquid into solid did not take place without disturbance. A solid substance takes up less space than a liquid one, so that between the first and second layer a cavity was formed if the cooling process was abrupt and the solidification irregular above the plastic region. The result, therefore, was that forces at work in the earth led to a shrinkage of the outer crust. In places the earth's crust folded itself round the core like a wrinkled apple as soon as the core got smaller; these wrinkles covered the surface of the earth with mountain chains and valleys which would have given the earth to-day the appearance of a fantastic alpine landscape had not other

## *The Origin and Development of Caves*

processes in the border zone between the earth and the atmosphere been at work, knocking down and levelling. For aeons rain and wind lashed every inch of ground, tore at the heights, raging with particular force at great altitude, as though intent upon smoothing away every height.

Our living space—in other words, the earth's surface—is by no means static: it is the scene of a perpetual battle between the inner volcanic and the outer atmospheric forces. If, as a rule, we notice little of this conflict, it is because incalculable ages have been needed to bring about these geological changes. Careful research has shown that, even now, mountains, including the Alps, are rising, that new land forms at the mouths of great rivers and that islands grow and disappear. Occasionally the primitive powers of nature stage a more impressive display, and then the earth bounds like a wounded beast, fertile land is flooded by the sea, hot springs spurt into the air only to dry up again, for the earth's crust is still being squashed, bent and torn apart. On the outer surface, of which man has taken possession, all the adjusting processes of plastic deformation can no longer take place because the material is too brittle and the rock strata too hard; thus the present-day earth crust is not nearly so compact a foundation as one is inclined to believe. More often than we know, fissures and cracks appear in it which may take thousands, perhaps millions of years, to close again. Caverns are formed, running for miles beneath the ground—a world subject to its own laws, the world of caves.

I have given only a brief sketch of geological events from the birth of the earth to the general formation of caves. Already it clearly shows the close connection between caves and geological history, and justifies a closer look at certain geological theories before asking ourselves the most important question: What is the origin of caves?

Let us look for once at the rocks which the nature-lover scarcely notices, if he gazes at the mountain peaks, with their ridges and crests wreathed in light cloud. Heedlessly he treads the sand, clay and gravel on his path; rarely does he give a thought to what lies underfoot.

And yet it is precisely the soil which is the key to the landscape and the vegetation covering it. Whether we are surrounded

## *Wilderness Under the Earth*

by a lake landscape with lush flowering meadows or a flat endless expanse of heather and stunted firs, or whether we stand in a gullied limestone region with coombes, clefts and bare rock faces we learn that it is due to the rocks and the soil that our surroundings bear these particular features instead of others. Rocks are not eternal. The forces of weathering work unremittingly to destroy them, and new types of rock emerge from their debris.

The ancestor of all rocks is magma. This is the term used for the ductile white-hot dough which lies embedded between the metal core of the earth and its some twenty miles deep firm crust. Gigantic forces are at work on this mass, forcing it with inconceivable power against the overlying crust of the earth. Where the latter is weak, the magma breaks through and a volcano is born. The red-hot lava cools and solidifies in the cold air and the cooling process continues in the solidified matter. Eventually it contracts and cracks into countless pieces which, for some strange reason, nearly always assume the form of hexagonal columns. This newly formed effusive rock is known as basalt. More frequently, however, the molten magma pours into beds of sediment, with which I shall deal later. In this way, too, are created rocks which, like basalt, we call igneous.

That was the primary group. To the second group belong the so-called sedimentary rocks; their cradle is usually the sea.

The sea beats against the coast; pieces of the cliff break off; and they are ground round and smooth by the action of the water. This is the *origin of pebbles, and of fine sandy matter* which, in due course, is carried far out to sea.

While the breakers sweep away more and more of the coastal cliffs, which migrate inland, the stony residue remains behind and gradually reaches still water. Here the fine mud sinks to the floor, filling in the interstices. New beds form on top of this, rising ever higher and in turn exerting pressure on the lower beds, as a result of which they become welded together and a new rock has formed. In a similar way, slate and clay are formed out of mud and loam.

In addition to these purely mechanical processes, chemical action is also important. The rivers carry down to the sea huge

### *The Origin and Development of Caves*

masses of gravel, sand and fragments of rock. In the course of extensive displacements, portions of the sea can become separated, in which salts concentrate often to saturation point, precipitating mainly chalk and gypsum. These substances sometimes form pure crystalline beds, but often act merely as filling or cementing material, amalgamating the scree into a rock.

A third cause of submarine rock formation is known—sea plants and animals. Snails, sea-urchins and many forms of sea-weed, for example, secrete lime, building enormous beds, just as coral creates reefs and atolls.

For millions of years these submarine rocks lie deep below the water. And yet their hour comes, for the bottom of the sea gradually rises. Ages pass and it rises still higher, the water retreats and new land is created.

All over the world, traces have been discovered of former sea bottoms—mussel shells and impressions of sea organisms. It is sometimes difficult to believe that a vast expanse of water, a primeval sea, once stretched over an area which to-day is mainland. But the visible testimonies of the past speak too plain a language, and we are forced to realize that nature is more powerful than man can conceive.

The impression of standing quite alone in the middle of the Continent on a primeval sea bottom is dwarfed by the effect of the actual mountain landscape and this wild untamed region with its towering crags which gives us some inkling of the titanic forces that were needed to raise these masses to the sky.

Nowhere is their effect—if we confine ourselves to Europe—to be seen more clearly for the unscientific observer than in the Alps, geologically a young mountain range which has suffered comparatively little from degradation. The peaks tower into the air from vertical walls and sometimes the range appears to be splintered into jagged edges like splayed fingers. Canyons breach the rocky walls and deep valleys cleave the heights.

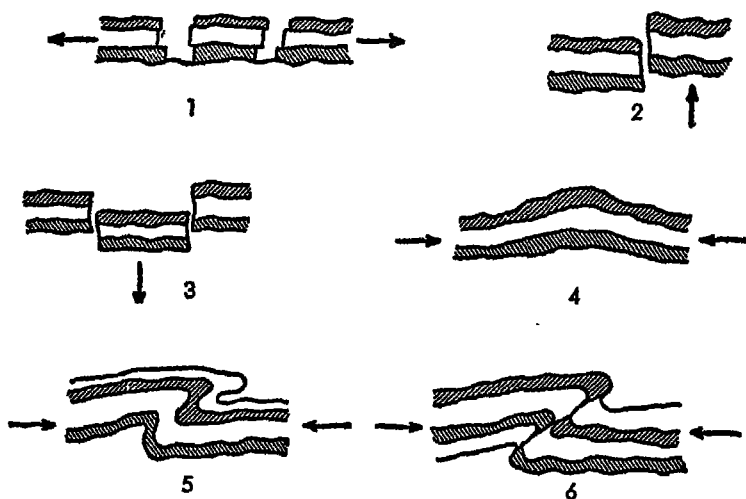
The intelligent observer, however, will not only recognize that the mountains testify to the powerful leverage exercised by the inner forces but he will also be struck by the fact that the forms are not always the same. What is the reason for this?

## *Wilderness Under the Earth*

It is impossible to give a simple explanation, but it is worth considering some of the causes of different formations.

At best we can differentiate between tension and compression. The usual results of tension are fractures, and this also holds good in mountains. Let us confine ourselves to the commonest original situation: a stretch of land covered by even beds is under tension. As soon as the strength of the beds is overcome, a rift opens and the complete strata are often torn into a number of adjacent masses (see Figure 1 below).

Perpendicular rifts can also originate when forces work in a vertical direction upwards or downwards irrespectively. In this



case the broken masses do not separate but displace each other (Figure 2). Geologists call this a "fault"; in such displacements rock rubs against rock, shattering all the material lying between. In the surfaces subjected to friction will be found striations or flutings known as "slickensides" indicating the direction of the movement, as well as the mass of fragments, crushed between the moving walls of the fault, which are called "breccia" (see Plate 15 opposite p. 177). Should one mass sink between two of the others a depression results known as a subsidence or a "graben" (Figure 3).

Complicated conditions result when the uppermost beds are

## *The Origin and Development of Caves*

compressed horizontally. Rocks do not allow themselves to be pressed together like a sponge; at the most they could bend upwards towards the surface or downwards into lower beds. Like a rucked-up carpet, the beds at the outset form waves (Figure 4), folding more and more until the bulge topples under the force of gravity, burying the lower strata (Figure 5). Every mountain climber will have noticed these rock folds and will have wondered how the hard rock could ever have been bent. Moreover, this is only possible in certain conditions, firstly, under enormous pressure, and secondly, when this movement takes place incredibly slowly. The elasticity of the rock, however, sometimes reaches its limit and then the fold breaks and tears, losing connection with the overlying bed (Figure 6).

The Alps are a result of this folding phenomenon. These mountains are no more than piled up, superimposed, and subsequently very much fractured, beds of rock. Geologists can follow these beds for miles, and reconstruct the previous situation.

The foregoing illustrations of the possible mountain building movements of the earth's crust merely give a highly idealized picture. In reality, the straightforward case never occurs; the original movements are always subject to subsequent complicated superimposition. This accounts for the infinite variety of the mountainous regions which, despite their great area, never repeat themselves.

The forces within the earth are not the sole effective agents. Externally, also, the elements cause destruction and levelling down, loosening and breaking the rock into fragments and transporting them down into the valley. If the inner force did not exist the mountains would be doomed to destruction; they would gradually become undulating downs and ultimately a marshy plain. The Alps, for example, would to-day be a minor range if an exceptionally strong folding movement had not taken place in the Tertiary Period.

What agents then are at work here? The most obvious is water. After a thunderstorm, when a previously dry channel is filled with rushing water, hugh boulders are washed away, trees are uprooted and soil is eroded. Water, however, is also



## *Wilderness Under the Earth*

active even when there is no rainfall. Each rivulet constantly brings down rocky material, and the round pebbles which are piled up in the valley bear witness to the mechanical rubbing and polishing work, which, although slow, continues without pause.

Chemical action by water is also effective. I will refer to this later.

Another important factor is frost. This is because water expands when it freezes and ice takes up more room than a similar volume of water. When water freezes in the joints and fissures the ice has an explosive effect and produces, year after year, gigantic quantities of rubble which is then again reduced into smaller components by water and carried further down.

The wind, too, is a great force in the mountains and plays its part in the general work of destruction. To a lesser degree we must mention plants which can excrete rock-dissolving acids and can also produce a similar effect to the frost by the penetration of their roots into crevices, thus loosening the rock.

With all these forces at work it is not surprising that the earth is in a continual state of evolution.

\* \* \* \* \*

As I am, in the main, discussing limestone caves, it is worth recalling that the birthplace of European speleology was the Istrian-Yugoslavian karst, the high, terraced plateau between Trieste, Ljubljana and Fiume which can be considered as the continuation of the southern limestone Alps. To-day the word *karst* is a term for a certain type of landscape which has been built of rock that is soluble in water.

Cooking or rock salt is an example of a mineral which is soluble. Landscapes, of course, are hardly built up out of salt for it dissolves too easily, but gypsum, dolomite and limestone are also soluble rocks, though to a far lesser degree. In any case limestone differs markedly from salt by its physical property. Pure limestone, i.e. calcium carbonate, is almost insoluble in pure water, but since carbon dioxide is always present in impure water, the carbonate is chemically transformed into the more soluble bicarbonate. A gallon of water at room temperature absorbs about 65 milligrammes.

## *The Origin and Development of Caves*

It is obvious that the resistance of rock to water is of decisive significance in the formation of landscape, since we know that erosion by water has one of the most important influences on the physiognomy of the earth's surface. On the basis of the rock's nature alone we can form a picture of the drainage. If the soil is formed of rock which is resistant to water, the latter wears away the top layer of humus and then flows over the rock, slowly burrowing deep channels and beds in it, but still remaining on the surface. It is a very different matter in permeable rock.

Let us presume that the water flowed away from the chalky bottom of a sea and that the ground was raised by earth movements: a new mountain range finds itself at the mercy of the atmosphere. The winds rage over it and the rain beats against the bare rock. What happens? However smooth and flat the limestone surfaces may be, the water will still find small depressions to follow in its descent. The solvent naturally works more powerfully on these, and the result is that these grooves grow ever deeper until finally canyon-like channels are formed several feet deep, leading to the next ravine. Ravines which were created at the birth of the mountains are positive evidence of limestone drainage. Naturally, one finds these just as frequently in all other rocks which were subject to tectonic forces—for purpose of water flow they are of little importance because they are generally too narrow. It is quite a different matter in the case of limestone. In it the water finds weak points where it can expand and bore out a network of underground channels, the first beginnings of a cave system.

The subsequent action depends above all on the hardness and also on the fissibility of the rock—variable characteristics, which show in themselves that the processes of corrosion and corrasion by water are highly complicated. Nevertheless, there are two clearly defined stages in the enlargement of cave area by water:

(1) When the joints and fissures are still narrow, the water fills them completely. This means that the whole pressure head of the upper columns of water operates on the body of water below.

(2) The water does not completely fill the joints and bedding

### *Wilderness Under the Earth*

planes, but in obedience to the law of gravity, follows a channel down hill. The most obvious difference between such "vadose" flows and the "pressure flows" of the first stage is the incapacity of the vadose water in stage two to flow uphill—in other words, vadose water behaves quite normally like the brooks and rivers above ground.

This contrast is important when we wish to classify particular cave forms. Firstly, we need only draw our conclusions as to the formation of the cave from the behaviour of the water. Let us begin with the "pressure flows". In our general observations that follow we must presume that water is available in sufficient quantities.

As long as the fissures and rifts are still narrow, the speed of flow will not be too great, for the friction on the bare rock has a strong braking effect. Rough parts of the rock, on the one hand, offer far greater surface for attack, but, on the other hand, increase the turbulence of the flow and therewith the purely mechanical abrasive erosion, so that the first visible effect will be a polished surface on the wall.

Now, the first obstacle having been overcome, the water pours ever faster through its canal system, gradually widening it more and more. With the increasing speed, however, the motive power also increases. Sand is carried along with the polishing effect of sandpaper on the walls of the tubes; small stones whirl through them with devastating effect. Corrosion (chemical erosion) and corrasion (abrasive erosion) work hand in hand. One of the most important features of fast moving liquids is vortex motion. At breaks, at a broadening out of the conduit or against obstacles, the water forms small whirlpools which apply great force in their vicinity and are capable of boring wide holes in the rocks, particularly when there is a sufficient quantity of sand and gravel to set up friction.

Vortex motion is also to be found in vadose flows. But whereas in pressure streams these eddies or small whirlpools can lead to all parts of the wall, when formed by vadose flow they always form downwards. Whirlpool holes in the roofs testify to pressure flow. The most important feature of vadose flow is that if found it always shows a downward tendency. It

### *The Origin and Development of Caves*

can reveal itself in deep-cut vertical trenches, in watermarks and grooves of all kinds, or merely by the fact that the course of the cave runs downwards uninterruptedly, while those which change their inclination can be attributed to pressure flow.

Unfortunately, such conclusions are not as simple as they would seem to be at first. Pressure flow is nearly always the first condition of cave water; even when the channels have been extensively widened and the water has long since begun to flow as a gravitational stream, traces of the original condition can be found and it is difficult to decide whether a considerable part of the expansion was under constant pressure or can be attributed merely to the flow of water subject to gravity. In addition to this, the transition from the first to the second stage does not take place abruptly but often over a very lengthy period of time. During this interval the water will alternately completely fill the whole space or behave as a normal stream according to the amount of water which is brought down by the rain or the melting snow.

The conditions are even harder to analyse since water has two possibilities of effecting rock: as static water or as percolating water.

Water stoppages can often occur; for example a channel becomes filled with rubble or sand so that the water has to look for other egress higher up; large chambers may have only small outlet openings, so that—once they are full—it takes a long time before the chamber is again dry; the cause can also lie in the open air when, for example, there is flooding and the water can no longer run away.

Static water also gnaws away at the rock, though only by chemical action; obviously only flowing water can have mechanical effects. The same forms occur as those which strong acids produce in metals—in the case under consideration, corrosion is simply decomposition caused by carbonic acid. Limestone and dolomite when under water containing carbonic acid look as though they have been eaten away by acids; not an even patch remains on the walls; they are furrowed, cornered, striated with rills, with an eccentric bas-relief of horns, arches, hooks, spikes and clubs. The floor comes off best, for small particles of mud deposit settle on it, forming a

### *Wilderness Under the Earth*

protective covering. The roofs on the other hand can suffer terribly: a tangle of close set stumps of columns often hang down from them—not elegant and clear-cut, but stocky, spiralled and gnarled—the normal structure of corroded roofs.

The water does not always reach to the roof and in this case special surface effects on the walls can be seen. Although the water is static, the surface is rippled and where the water-level joins the rock, mechanical forces come into play; but chemical action, too, can become more intensive, since the bicarbonate solutions are led off by the gentle eddying and replaced by fresh, acidiferous water. This explains the presence of water-marks in the shape of notched rings round the cave, representing the most frequent water-levels. A feature is that they run evenly round the whole chamber, uninfluenced by the bedding of the rock. One must be careful not to confuse these with similar phenomena which have been caused by water solution; the latter do not denote water-levels, but are grooves which the water has eaten into softer beds of rock, for in sedimentary rocks there are naturally beds of different texture which will vary greatly in their susceptibility to erosion. If the beds are quite level it is often impossible to determine whether these grooves are watermarks or proof of less resistant strata.

We must now examine the work of seepage water. By this we mean water that moves slowly in a sheet over the wall, penetrating the most shallow pores and clefts, and is even capable of climbing upwards by capillary action, like ink absorbed in blotting paper. This causes the mountain dampness, which is closely related to the water vapour with which the air in most caves is saturated, and trickles down as condensation in places which happen to have remained dry up to that time. It is also capable, however, of collecting in small gutters which eventually dry up or join a larger runnel. Seepage water which ceases to flow dries up unless it forms drops, which in time can make holes in the hardest rock by their impact when they fall. On the other hand, the chemical power of seepage water is quite capable of attacking the rock, and it is not difficult to discover the traces of this; they are the grooves and flutings which develop in the line of greatest flow. The best examples of this are the subterranean furrows which can vie in their wealth of

## *The Origin and Development of Caves*

form with those to be found above ground, particularly in karst regions.

Seepage water has one more peculiarity: it is usually too weak to carry away the particles remaining undissolved. These are those alien parts of the limestone which are not soluble in water and remain therefore as firm, sandy or clayey components. Running water usually carries them away and does not deposit them until it becomes sluggish. In the case of ground water, it often happens that these clayey deposits remain at various places on the walls and roofs, until eventually they are covered with a layer of equal thickness. They must not, however, be confused with the vestiges of some earlier flooding, which could be plastered over the solution residues.

A particular type of water cave is that found on the sea coast. This is how it is created: since tidal water works most powerfully at surface height, its maximum effect is on the rocks of steep cliffs, which it gnaws and undermines, occasionally boring out huge, horizontal systems. It is on the same principle as the formation of the watermark rings except that here it is a question of water coursing from outside which works mainly through its mechanical motive power.

The most famous coastal cave is the Blue Grotto in Capri, one of the sixty-seven caves of that island. Inside are to be found artificial platforms, built with Roman mortar, showing that it was already well-known in antiquity. In 1826, the Breslau painter Kopisch swam into it; he ranks as the man who rediscovered it, although it was mentioned in the literature of the seventeenth century.

Its creation consisted of two phases. At first a horizontal entrance was formed some 13 feet above the present sea-level, which was the ancient ground water-level. Later, in a period when the sea-level lay 65 feet deeper than now, the main chamber was created. The Blue Grotto, as a consequence of roof collapse, acquired such height that ultimately a break through into the parts lying above resulted, and then the latest cavern, hollowed out by the beating surf, was flooded by the sea. Boats in which one enters the Blue Grotto to-day use the lower entrance to the upper horizontal system; the original arched entrance lies well below the water.

## *Wilderness Under the Earth*

The great attraction of this Grotto is the azure blue light from which it takes its name. The fairy-like illumination is due to the fact that the light can only penetrate through the entrance which lies below the water, bringing with it the wonderful colour of the sea. Since the surface from below is almost invariably rippled, the predominant part is reflected once more in the depths—objects dipped in the water seem to shimmer.

All these origins of cave-formation—the flowing of water under pressure, the vadose stream subject to the laws of gravity, static water and the drying up—seldom work independently; they relieve each other, work simultaneously or combine to produce mixed forms which cause great problems to the geomorphologist, if he tries to discover on the site what kind of cave water is applicable to a particular chamber. But that is not all. The second great factor in the formation of caves—which I have so far purposely avoided mentioning—is rock fall or cavern breakdown which destroys and renders unrecognizable the forms created by the water.

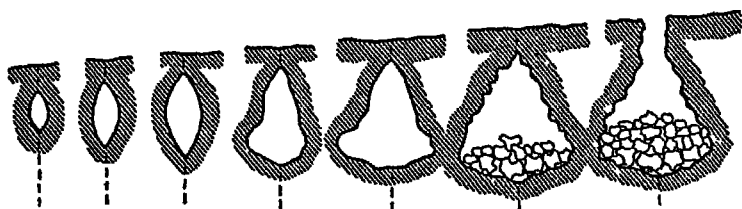
\*            \*            \*            \*            \*

That other factors apart from the power of water must be taken into account in the formation of caves is obvious to anyone who has seen the piles of rubble which are to be found in many of the Austrian Alpine caves, but which are also present in a great many small caves. The power that causes this devastation is the weight of the rock itself—each layer carrying the weight of the layers above. As long as the rock is compact it can bear this pressure. But if in some way a cave has been formed—it does not matter whether by natural or artificial influences—so that the roof beds are left in the air, then elastic bending occurs under the weight of the upper strata, but in limestone rocks the elastic strength is not great enough completely to prevent the roof parts collapsing, provided enough free space is available to receive them. Erosion by water creates this free space in natural caves.

Vadose water can have its effect in depth—then high, narrow canyon-like corridors are created. They can, however, also work laterally, for example when a vulnerable bed which puts up no particular resistance to the water is cut while below

### *The Origin and Development of Caves*

it lies an extremely tough one. What happens? The cave extends more and more in a lateral direction; the walls become undercut; the heavy rock above bends; splinters of rock break off from the roof and splash into the water which carries and rolls them away and mechanically reduces them in size, and also attacks them chemically, so that edges and projections are smoothed away. This is the origin of rolling scree which piles up in the large caves or becomes pulverized into insoluble debris. Here can clearly be recognized the team-work of water power and mountain pressure. Were the water not to take over the transportation, the cave chamber would soon be filled up with particles of scree which would occupy more space than compact rock because of the air spaces between the fragments of rock. For as long as the water excavates under the walls, thereby increasing the roof surfaces, the breakdown continues—and it will still fall for a while even when the water dries up. A very common picture, in fact, of the abandoned bed of a cave river is a vat-shaped vault, the lower part of which is filled with rubble.



This seems to be a plausible explanation of the formation of caves, but in practice there are many variations from the simple example of a water channel among undisturbed rock. I mentioned earlier that water prefers joints and fissures when seeking a path. A fissure, however, represents a considerable disturbance in a rocky mass. Our example may hold good if it is a question of hairbreadth joints, and provided the waters took this and no other path and remained without any other influence, which is unlikely. Sometimes, however, a looser joint will betray its presence by a deviation from the ideal tubular section—then we find those Gothic profiles which might have been hewn by a sculptor.

Now it is quite understandable that water prefers to use the



### *Wilderness Under the Earth*

larger fractures and joint fissures when they are available. In many limestone regions they are rare, but the Alps are criss-crossed by faults and joints and this is precisely the reason why they contain so many giant caves.

Faults are the favourite routes for water hollowing out the mountain; the friction caused by rocks rubbing together has also wreaked considerable damage in the vicinity. Not only is the material between them pulverized—here and there the slide does not go easily for spurs may become interlocked, a section of the beds may rise above the other, and, in this case too, cavities are often formed without the influence of a cave stream, which will only take over later. If it now begins its undermining work, it naturally has a more rapid success than arteries of water in undisturbed rock. The already fragmented material quickly falls from the roof, an easy prey to solution, and in a short time huge chambers, giant halls and rifts have formed. In such regions breakdown begins at the first penetration of the water, while in other places some enlargement must first be made. Here, too, there are considerable differences, dependent upon the nature of the rock, such as texture, bedding, porosity, and elasticity, and on the tectonic structure such as folding, jointing, and cleavage.

A close succession of joints forms a zone particularly susceptible to breakdown. These indicate regions of strong tectonic strain, provided they have not expressed themselves in tangential faults. They are actually the favourite conduits of cave waters.

The intersections of joints are also some of the commonest localities for cave building. In rock masses intersected by only occasional cross-joints we find huge, mainly high-vaulted caves developed at these intersections. When the latter are at great depth, pots result which are the greatest obstacles to cavers.

When a whole series of joints or faults cross, then it is almost certain that the caves formed will be very large. The "Ice Cathedral" of the Geldloch in the Ötscher Pothole and "St. Helena Hall" of the Tantalhöhle are examples of this.

This bewildering number of possibilities for cave building naturally makes the task of the theoretician much more difficult. Only very occasionally do we have positive proof of

### *The Origin and Development of Caves*

the way in which a cave has been made, and then it is usually some exceptional case in which only the type of building is in question. The Bodenberg Potholes, for example, can be traced to purely tectonic causes; the gaping walls correspond so perfectly that each spur of the one wall would fit into a depression on the other. The hall of the Great Peggau Cave owes its size to static water which was responsible for the variety of its wall formation.

So far we have only discussed the formation of caves. It is unnecessary to examine rock falls in detail, for the very causes which produce the cave could also destroy them again. The hollowing out of the limestone masses cannot go on for ever. One day the moment arrives when the destructive power of weathering outside reaches down to the cave and it collapses like a dilapidated house. Usually the roof becomes too weak or the cave too extensive, and then comes the beginning of the end with the collapse of the roof. Such sinks caused by collapsed caves are characteristic features in the Alpine limestone landscape above the surface: they are the famous shakeholes in which water collects to be sucked up with a gurgle in the potholes.

Finally, in limestone regions whole valleys can be formed by the collapse of cave systems. At first these valleys looked like ravines until, as a result of weathering, they assume the form of ordinary river valleys.

It is easy to see to what extent the surface form corresponds to the subterranean conditions. In bare karst regions, i.e. without a layer of humus and therefore without vegetation, the network of joints on the surface, which forms the framework of the cave system below, can be detected. This relationship has to-day been subjected to such intensive study that by merely observing the external landscape we acquire some idea of the caves which lie below. But although now we have a wide knowledge of the principles of cave formation, many important details are unknown. It is perhaps profitable to make a closer investigation of these mysteries.

\* \* \* \* \*

Before we broach some of the interesting problems of caves, in particular the question of their age, let us take a look into the past.

## *Wilderness Under the Earth*

The following table compiled by Dr. Erich Arnberger will give the reader a clearer picture. It is incomplete because I have only made use of that part of his table which refers to cave formation.

AGE	SYSTEM	SUB-DIVISION	YEARS BEFORE THE PRESENT DAY
Cainozoic	Quaternary	Alluvium	20,000 years
		Diluvium	600,000 years
	Tertiary	New Tertiary	
		Older Tertiary	
Mesozoic	Cretaceous	Upper Cretaceous	60 million years
		Lower Cretaceous	
	Jurassic	Upper Jurassic=Malm	120 million years
		Middle Jurassic=Dogger	
		Lower Jurassic=Lias	
	Triassic	Upper Triassic=Keuper	160 million years
		Middle Triassic=Mussel	
		Lower Triassic=Bunter sandstone	
Palaeozoic	Permian	Upper Permian	200 million years
		Lower Permian	
	Carboniferous	Upper Carboniferous	230 million years
		Lower Carboniferous	
	Devonian	Upper Devonian	300 million years
		Middle Devonian	
		Lower Devonian	
	Silurian	Upper Silurian	360 million years
		Lower Silurian	
	Cambrian	Upper Cambrian	490 million years
		Middle Cambrian	
		Lower Cambrian	560 million years

In the Cambrian Period, Europe was almost entirely covered by the sea. Little change took place in the Silurian Period, and not until the Devonian Period did Central Europe emerge as an island out of the water. In Carboniferous times the coal beds were formed and the mainland gradually expanded. This mainland formation continued even during the violent volcanic

### *The Origin and Development of Caves*

eruption of the Permian; and in the Triassic the sea receded, although minor inundations often reclaimed the land. Germany was at that time covered by a shallow inland sea. This frequent change of land and sea favoured the laying down of limestone beds, which is shown in the name, Mussel Shell Lime—the alternative denomination of the Middle Triassic; in the Upper Triassic, also, important beds were formed: for example, the main dolomite of the Alps and the Dachstein limestone, the site of most of the giant caves in the Salzburg area.

In the Jura, too, the powers of nature were at work creating foundations for caves—above all the dolomite strata of the Franconian and Swabian limestone regions. The Cretaceous brought further inundations; the greater part of Central and Southern Europe was flooded and not until this period drew to a close did the sea recede until eventually the water and land distributions in the Newer Tertiary approached present-day conditions. The main phases of the Alp building took place in the Tertiary period—a stormy time with violent volcanic eruptions during which the Alps, at the time gentle foothills, were opened like a fan and assumed their new aspect as high mountains.

And then came the Quaternary which has continued to the present day. This is the Period of the Glaciations during which the Northern Hemisphere was repeatedly covered with ice, interrupted by warm interglaciation stages though it is not yet quite clear how often these changes took place. Geologists have classified several main glaciations in the Alps (in the sequence of the most recent to the farthest removed in time: the Würm, Riss, Mindel and Günz glaciations or cold periods, although it should be noted that increased usage is made of the general terminology proposed by Zeuner (1945) who uses the equivalent terms of Last, Penultimate, Antepenultimate and Early glaciations).

As time progresses, these epochs will probably be subject to classification into sub-divisions. It is not absolutely certain whether we are actually coming out of an Ice Age, still in the middle of one or in an interstadium.

The first man in Austria to be dissatisfied with the vague dating of the age and formation of caves was Hermann Bock of

## *Wilderness Under the Earth*

Graz, who became famous for his assaults on the Dachstein cave system. From the surface forms, the lapiez and grykes, from the vegetation and the strikingly coloured veins of rock, he drew his conclusions as to their development down to modern times and produced a vivid picture of the history of the Alpine limestone. He presumes the beginnings of cave building to be in the age when the lime beds were formed, for the sea water had already attacked the young rock as it was deposited. In any case these caves were usually filled with sediment which was introduced as younger deposits into the older formations.

Naturally Hermann Bock's observations apply to the Austrian high Alpine caverns, particularly to the Dachstein caves. He sets the beginning of this cave horizon in the Upper Cretaceous and the phase of their strongest development in the Tertiary. As a proof of this he quotes the "Valley Stairs", if we take a closer look at this we shall soon understand what he means.

We have already seen how the lower levels of cave systems progressively work down, keeping pace with the deepening of the valleys on the surface. Now this deepening of the main surface water course does not take place at an even speed; there will invariably be periods of rapid progress with intervals of repose during which the level will stay unchanged for a considerable time. Traces of these intermediary stages can be found to-day in the terraces formed by the rock washed down by the river which form a series of steps—the "Valley Stairs".

In order to determine the age of a cave horizon, it is sufficient to find the corresponding valley level, the geological date of which is often known.

Bock has also developed a definite theory on the manner and fashion of cave formation in the high Alpine regions. According to him, the crux of the expansion process lies in the excavation of the rock by swift-flowing water under pressure and loaded with silt so that the cross-sections of the cave passages are of the same evenly rounded form that can be seen to-day in water-filled cave tubes, but in the former case enlarged to gigantic proportions.

This theory, which postulates that most of the large passages

## *The Origin and Development of Caves*

in our big caves were once river channels filled with water, is strongly opposed by a number of scientists. Otto Lehmann has pointed out that in the chemical field alone, the same type of chamber can be produced as through pressure streams, namely, when nearly still water, rising and falling during the year, alternately fills spaces in the cavern only later to abandon them. Walter Biese, too, has proposed another possible way to form regular vaults—the previously mentioned cavern breakdown producing the most suitable shape to withstand the pressure of the rocks above.

There are several other reasons why geologists have taken so much trouble to find an explanation for the existence of cave passages with circular cross-sections, the most important being that immense volumes of water under pressure must have been needed to fill the giant caves of our Alps—volumes of water which could not have existed unless we reckon with a far greater rainfall than at the present time, or if we accept far greater catchment areas than our geological knowledge of prehistoric times allows.

The question as to how caves came into being has not yet been fully explained. There are a host of conflicting opinions and the champion of each theory finds sufficient proof for his own, so that to date no agreement has been reached. Nor can there be any hard and fast rule, because cave building takes place in so many different ways—by means of water under pressure or of vadose streams, through variations in height of the local watertable, or as a result of cavern breakdown. For each theory there exists a cave to which it would apply, but there are many more in which several of these forces have worked either in sequence or simultaneously, thus corroborating each individual hypothesis.

Thus we must never generalize: there is no single hard and fast rule for the formation of caves. The history of a cave system can only be reconstructed by the most accurate investigation of its form and its surroundings within the ambit of the particular local conditions which are nearly always unique. This requires a great deal of work. Countless observations have to be made, plans of the caves must be drawn, shapes photographed and compared, temperatures measured and rocks

### *Wilderness Under the Earth*

tested for their mechanical solidity and chemical content. Only then, perhaps, shall we know how a certain cave came into being, and in what geological period the phases of this development took place, for Hermann Bock's remark of twenty-five years ago still holds good to-day: "The rocks can speak to us if we could understand their language."

## *Chapter Six*

### TANTALHÖHLE—THE MOST DIFFICULT CAVE IN EUROPE

I STRODE ALONG the short-cut which leads down from the Oedlhaus at the fringe of the Eisriesenwelt to the railway station and the Konkordiahütte. Ahead of me lay my objective, the Hagengebirge range, which is separated by the deep gorge of the Salzach from the Tennengebirge on whose slopes I was now wandering.

The Eisriesenwelt has held a generation of Salzburg speleologists in thrall, the first problem being the Eiskogelhöhle beyond the plateau, discovered by Gustave Abel. Now the younger generation had been given another task: the Tantalhöhle in the Hagengebirge. It was discovered by Alfred Koppenwallner, after a systematic search, a unique yet noteworthy triumph for modern speleological methods. His reasoning ran approximately as follows.

One of the particularly noticeable faults which runs through the Tennengebirge continues in the so-called Ofenrinne down to the valley, and can be picked up again in the Hagengebirge. There, on the east wall of the latter range lies the Scheukofen, a huge cave entrance into which the discoverers penetrated to a distance of 800 yards before being halted by a sump. According to rumour, further progress had been possible in the distant past. To-day the Scheukofen is considered as one of the many unsolved problems of the Salzburg cave region. Koppenwallner was of the opinion that other caves could run into the fault. For days on end he scrambled over the crags of the Hagengebirge, exploring every doline and every fissure, looking behind every rocky spur and limestone cliff, refusing to be discouraged although night after night he returned home without success. Eventually his obstinacy was rewarded. One evening when the



## *Wilderness Under the Earth*

sun was already low on the horizon, warning him to return, he caught sight of a terrace above a channel running down almost vertically behind which the rock had formed into an arch. An overhanging ledge masked the part that lay behind, and from below it was impossible to decide whether or not it hid a cave entrance. More from conscientiousness than in hope, he climbed the steep face, reached the platform and was about to turn back, disappointed. Behind a small snow-covered ledge, boulders had completely sealed the entrance from floor to roof. At certain spots in the background, however, the snow had melted and Koppenwallner, bending down to find the reason for this, noticed that the wind was rushing through the cracks—a cold, damp, noisy draught. He had no time to begin clearing away the boulders, but he was convinced that his search was over, for the strong wind was the sign of an extensive cave system.

This happened in 1947. Since then it has been possible to explore beneath the mountain. The first assaults lasted from ten to twelve hours, but later the visiting times increased until, finally, the Salzburgers had to work to a programme—a twenty-four-hours' shift with a similar period of rest—and this routine once continued for nine days. Finally, this, too, proved inadequate and the pioneers decided to camp for several days in the cave, since the farthest point attained at the time already required several days to reach. In the meantime the reputation of the cave had crossed the Austrian borders; it was considered then, as it is to-day, the most difficult cave to visit in the whole of Europe.

These thoughts ran through my head as I strode downhill through the trees and came to a bramble-covered clearing not far from the start of a broad woodcutters' path.

A few minutes later the train arrived, bringing my colleagues for the tour we had planned—the discoverer of the cave, Alfred Koppenwallner, and his brother Xaver, Albert Morokutti, the well-known mountain climber, Kurt Schoeller, and two girls who would remain at the entrance during our tour, and finally a Yugoslavian guest, the geographer Ivan Gams from Ljubljana. A little later our party was joined by Dr. Erwin Angermeyer, one of the original exploiters of the Eisriesenwelt,

### *Tantalköhle—the Most Difficult Cave in Europe*

to whose kindness I owed my participation in the tour. He had come to do some work at the cave entrance.

After a final civilized meal in a pleasant inn garden, we took the so-called Upper Road into the Blühnbachtal, some of us on motor bicycles, others, including myself, on the mudguard of a forestry tractor. Although I was somewhat shaken about, I enjoyed the charm of this neighbourhood,—a game preserve for ibex which could only be visited by special permission—particularly the pretty Blühnbach castle built by Archbishop Wolf Dietrich in a wood-girt hollow with towering snowy peaked mountains to left and right.

At last we reached an old bridge and turned off to the right where a hedged path led us into a coomb. Above us we could hear a plaintive baa-ing. I looked in all directions expecting to catch sight of one of the rare ibexes, but was taken aback by Albert's laughter. "That's the Koppenwallner brothers," he said. "That is the signal we use so as not to disturb the game." Cupping his mouth with hand, he gave the answering call. It echoed away into the distance.

The Salzburgers were the most considerate hosts. At every 1,600 feet flasks of tea had been provided to quench our thirst in the summer heat. The climb began in earnest near a gushing waterfall, for here we left the path and entered a rocky region where we had to do some work on the rope. At about 5,300 feet we climbed out of a gully on to a plateau where our colleagues were waiting for us. I was very surprised as I took off my pack to see a wooden hut which had not been visible from below; it was protected from the weather and perched in a niche like an eagle's eyrie.

On the following day, we scaled the 220-foot steep rock face beneath which the cave entrance lies, overshadowed by an enormous rocky slab in the shape of a triangle standing on its apex.

It had been impossible to clear the debris, which formed a pile 20 feet high, and we had to force our way through sharp wedged-in boulders. Albert was the first to enter and I followed, lowering myself slowly into the boulder chamber; the cold wind blew round the corners, piercing our clothes until we felt that

### *Wilderness Under the Earth*

we had been plunged into icy water. My lamp went out and I had to rely on my sense of touch, winding my way like an eel through the narrow passage. A cavity opened below me. I fished with my foot for a hold. Albert lit up the route with a torch from below and I found a ledge from which I could go deeper.

Now came the conveyance of the packs. I had to be particularly careful for the boulders could not be trusted and many of them began to wobble as soon as I trod on them too firmly.

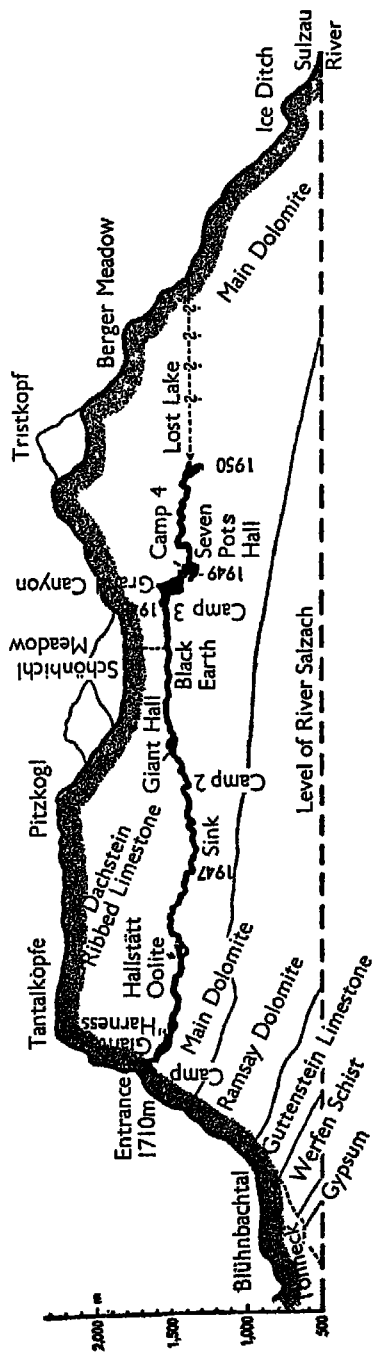
Eventually our party reached the first hall, but unfortunately Dr. Angermeyer could not come with us because the passage was too narrow for him and, to his regret, he had to remain outside—a disappointment for one who had first crossed the Sturmsee in the Eisriesenwelt and was now an elderly man. However, Bruni Hoffmann had joined us because it was her ambition to be the first girl to reach "The Grand Canyon".

The ice hall narrowed to a fissure and we descended 50 feet on a rope ladder. For a quarter of an hour, we proceeded in a northerly direction, step by step, deeper and deeper. 660 feet below the entrance level we came to "The Gallery of the Deluge". Then in turn we passed "The Gallery of the Thousand Hands" by "The Stony Lake" and the so-called "Funicular". Here the last pathetic remnant of the path suddenly fell away vertically; a wire spanned the gap, and on the far side the horizontal passage continues at a slightly deeper level.

"This always held us up for a long time," said Fred. "We left our packs on this side, lowered them one by one and then had to haul them up from the other side. Now the sacks are hung on the taut wire by karabiners and slung across on a line. Naturally we cross in the same manner."

Xaver hung a karabiner on the wire, secured it to his lifeline and began to descend. For a joke his brother let him hurtle across the chasm without braking and stopped him just before he reached the far wall.

"Your turn now," he said. But I preferred to make my way down a chimney and climb up on the other side. Ivan took one look at the "Funicular" and followed my example. In the meantime the packs had been transported and now we advanced uphill through "The Gothic Way", a beautifully



**A Cross-section of the Tantalhöhle in the Hagengebirge**  
(Salzburg)

### *Wilderness Under the Earth*

regular natural tunnel, past "The Maiden's Fountain", a modest waterhole at which we filled our lamps, and over "The Maiden's Leap", where one has to stride across a pair of boulders as large as a house.

I lagged a little behind intentionally. It was a very romantic sight, this heavily-laden column of men making their way through the subterranean wilderness, lit only by the acetylene lamps, following each other with heavy, careful steps. Their movements made the reflection of the light quiver on the floor and their shadows were enlarged and distorted to giant size on the walls. Their breathing was clearly audible in the silence, and a spoken word, a comment on the difficulty of the path, or a disgruntled cry at some piece of clumsiness, echoed eerily under the vaulting.

I was beginning to see why this cave, in which one has to descend more than three thousand feet, is considered the most difficult in the whole of Europe—and possibly in the whole world.

The horizontal stretches are of short duration and beset with constant obstacles—ladder descents where the equipment must be lowered or raised, squeezes and piles of debris over which one has to scramble. Such difficulties, of course, are to be found in other caves, but here it is the constant repetition which demands so much effort. "If we went on at this tempo, we could reach the end in four days," said Albert.

The cave, however, still held plenty in store for us. At one spot the path in its full width was broken by a deep chasm and we were forced to climb round it like flies on a wall, holding on to an aluminium line. The weight of the whole body and the load carried had to be taken on one hand so as to keep the lamp free; we clutched on to the line with our feet only skimming over the rock. I cast a look downwards but could see nothing except pitch darkness.

We continued on our way. A detour to "The Funnel Labyrinth", "The Pointed Pillars", "The Cloisters", then a horizontal stretch, "The Hall of Meeting" and "The French Slide". Here I was almost in despair. I had to climb a clay face of about 45°, inclining towards the right side of the gallery, with a drop of several feet below. I was wearing crêpe-soled shoes

### *Tantalthöhle—the Most Difficult Cave in Europe*

to which, after the first steps, 5 inches of clay were already sticking. I climbed one step only to slip back two, ever closer to the abyss. Finally I fell to my knees and climbed up on all-fours.

"Our French guests on the last expedition did not do much better," said Albert, "so they put thick bands round their shoes and ran to and fro over the sticky clay like weasels."

Next we came to a strange natural phenomenon, "The Spiral Staircase". The gallery here made a full circle round a thin column of rock up to a higher storey. One could hardly imagine the mechanical power of the water, which must have swirled round here thousands of years ago.

And then obstacle after obstacle. "The Sandpit", the steep terrace down to "The Meander", "The Canyon Descent", "The Mud Pitch" to the two "Waterfall Halls", "The Bridge of Sighs" to the pitch into the "Dolomite Rift"—the furthest point reached by the 1947 expedition.

From here we descended to "The Sink", the deepest part of the cave, a cauldron with apparently no egress. This was our first halting place. We sat down on the dry clay floor, and unpacked our provisions.

"Where do we go from here?" I asked Fred.

Chewing a hunk of bread he pointed to a rift in the rock and a hole in the floor. "This is where 'The Sink' begins. When it rains outside this chamber is filled with water. Look up there," he added, pointing with his knife to a spot on the wall. "About fifteen feet up you can see a piece of greaseproof paper which we threw away last time. The water has lifted it up there."

"We always have to count upon being cut off," interrupted Albert. "We have a big store of provisions down there and we could hold out for quite a time. We have also laid a telephone line in case of accident so that we could get in touch with a rescue column."

Ivan, the Yugoslavian, his brown beret on the back of his head, listened attentively for he understood German perfectly although he did not speak it very well. Now he asked whether any of the Salzburgers had been marooned.

"Not yet," replied Fred. "But we once found 'The Sink' full of a brown, clayey brew. We tried to dam up the entrance

### *Wilderness Under the Earth*

through a clay wall to stop the leakage and we succeeded at the second attempt. The first time when I tried to creep in, the dam broke and I took a pretty good slime bath."

After half an hour we were on our way through "The Sink". We tied our packs to our legs and dragged them after us. The Salzburgers had a few three-foot sacks with jute thongs which could be packed tight, but I had only my ordinary rather clumsy overloaded ruck-sack. The effort of pulling this shapeless object through the narrow rift infuriated me, as the material kept catching on snags in the rock. In the narrow tubes I could not turn round and kept tugging desperately on the straps. Eventually I forced it through, but heavens! what did it look like? On the following stretch through "The Bone Yard", a part of the cave whose floor was covered with clay concretions—a medley of yard-long pinnacles and fragile flat plates—my possessions fell out through the rents, and Rudolph, who was behind me, kept on picking up my slices of bread. This ridiculous state of affairs continued along the wide path to "The Ha-ha Pitch", "The Lawyer", "The Oedl Squeeze" and down the crawl to "The Hanging Boulder".

All my bones ached from my long crawl with a heavy pack, and I thought it was a mirage when we suddenly came into a Dante-esque chamber, its bottom coated with clay, and a hut appeared in the light of our lamps—the Bivouac hut.

This cosy shelter, 5,000 yards from the entrance, is a little marvel. In a series of long marches in 1949 the Salzburgers carried in copper alloy sheeting, steel props and plywood boards, and built a little hut to the specifications of Wilhelm Schaup and Richard Palfinger, who lived in Salzburg at the time and became enthusiastic speleologists. It is a little over 4 feet high and roomy enough for 5 men to lie close together.

By this time, it was seven o'clock and we were delighted to be able to dump our packs. Xaver got the stove functioning at once. We took off our shoes and overalls and I crept into the bivouac for the first time. Could there, I thought, be a more comfortable shelter than this unique hut in the heart of the mountain? We sat in a circle round the cooker which threw out its welcome warmth, and soon we were drinking hot tea. Air-filled mattresses were ready to lie on and on one of the walls

### *Tantalhöhle—the Most Difficult Cave in Europe*

was a shelf of tinned foods—iron rations in case “The Sink” should be flooded. I had to get outside again; my trouser leg had a three-foot tear and since I was loth to take this damp article of clothing into the clean hut, I sat down on a rock to repair the damages by the light of my lamp. The muffled voices of my comrades came to my ears from the hut. All manner of thoughts passed through my head. It seemed to me incredible that I was really sitting here doing an everyday chore a day’s march from the outside world with three thousand feet of rock above me and at a temperature of 2° C. (36° F.). I thought I must be dreaming. Then Albert called me into the hut. A fragrant soup was ready and I was quickly persuaded of the reality of our situation.

We retired early. Since there were seven of us, two had to sleep outside, so Xaver and Albert took their down sleeping bags and hollowed out nests for themselves in the clay. Since I was a guest and had only brought an ordinary blanket I was allowed to remain inside.

We were already awake next morning at four o’clock. The cold made our skins tingle and drove away sleep. Steaming coffee soon roused us. We filled our lamps and made our preparations for the second day’s trek, and there was a loud burst of laughter when Xaver discovered that Bruni had brought a toothbrush with her; there were no pools of water at hand and the precious liquid had to be kept for drinking and for our kerosene lamps; washing and cleaning our teeth were forbidden.

While the outstanding features of the path to the bivouac had been breadth, emptiness and barrenness, its character changed completely during the second day’s march. At the outset there were a few difficult places. The most unpleasant was “The Blocksberg”, a boulder slope as high as a house, which in places was so loose that it sometimes collapsed at the slightest touch. Dangerous situations could easily arise, and on one occasion the leader of the Tantalhöhle expedition, Gustave Abel, only managed to save his life by a daring spring from a loose boulder onto the “Sarcophagus” while the other debris thundered down like an avalanche. On the last expedition a way round it was found; this meant covering a lot of ground but



## *Wilderness Under the Earth*

there was no danger. Then followed long horizontal corridors with an unusually uniform elliptical roof about 20 feet high. Here our progress was in the nature of a stroll, the only snag being our cumbersome packs. The path led into "The Giants' Hall", the most impressive chamber in the system, for when one emerges from the corridor one has the impression of coming out into the open air and involuntarily looks up to the roof expecting to see the stars.

I had lagged behind with Albert near a little lake on the detour round "The Blocksberg" and did not reach "The Giants' Hall" until the others were at the far end. We could hardly see their lamps and their shouts were barely audible. It is an enormous hall and it took us a quarter of an hour to cross it.

This was followed by another breakdown zone. We climbed down over huge rocking boulders, the largest of which was very aptly called "The Church Roof". A second pile of boulders loomed ahead and we had finally reached the end of the barren, tortured region. We were now in a less hostile section with a graceful vaulted roof and walls somewhat reminiscent of Baroque architecture. "The Beautiful Path" began.

There was every sign that we were now advancing along an abandoned river bed: in places the floor consisted of 30-foot thick gravel deposits. Ivan gave a cry of pleasure. He had discovered a rimstone pool filled with clear water, and with the inner walls of the basin covered with crystals. As we stood there open-mouthed with admiration a shout came from Rudolph who had hurried on ahead—he too, had found something remarkable. On the roof and walls and even on the gravel deposit, glittered fragile, milky white, coral-like aragonite blossoms. The further we advanced the thicker and taller grew these flower-like formations until they reached their peak of luxuriance. We passed through "The Aragonite Door", a portal-like narrowing of the passage, thickly strewn with the crystal blossoms and eventually entered "The Hall of the Stone Flowers". In every nook and cranny the little crystals sparkled, forming a striped pattern on the walls. In between lay broad bright coloured galleries. The blue-grey background of the rock was coated with a network of white mountain milk; rust red surfaces were covered with black fungoid formations. At

### *Tantalhöhle—the Most Difficult Cave in Europe*

the heart of this region lies "The Hall of Black Earth"—a gloomy chamber smothered with a blackish-grey deposit which has been washed in. A number of snail shells had been found here, a sign that the overlying rock was comparatively thin—1,000 feet—and that there was a communication with the outside world through clefts and fissures.

"St. Helena Cathedral" follows "The Hall of the Stone Flowers". It is adorned by the most beautiful formations of the cave, "The Canopy", a gigantic stalactite curtain of crystallized white calcite. Not far away is Camp 3, the "Palais Bonaparte", a rocky niche in the wall. We sat down at the entrance and spread out our provisions on a broad level slab. I was ravenous; it was evening once more and this was the first bite we had had all day. It is a wonderful feeling to shed your heavy pack and to sit down for a rest, but after a few minutes the warmth produced by the food leaves the body and you begin to shiver. Then you want to get on the move again.

With a look of expectation on his face Fred rummaged in his rucksack, and brought out an object wrapped up in a cloth. It turned out to be a portable radio and he wanted to see whether reception was possible inside the cave. He turned the knobs, the dial lit up and a faint voice soon echoed through the chamber. This was another of the great wonders of my subterranean tours for it was, indeed, astonishing to hear this calm, friendly voice in the limestone wilderness below, separated from civilization by miles of barren galleries.

We did not listen for long. The doyens of the Tantalhöhle, the brothers Koppenwallner and Morokutti, got ready to move off; Ivan Gams studied the giant aisles of the cathedral while Rudolph went on eating, knowing that everything he put into his belly would lighten the load to be carried. Bruni and I were idle for a moment. We tuned into dance music and were soon waltzing on the uneven floor of the cave. I could not help thinking of a masked ball, people in fancy dress in gaily bedecked rooms, enjoying the pleasures of carnival. Here we were dancing to get warm.

The short rest had done us all good. Albert now led us along a short stretch to "The Grand Canyon" where a declivity of

### *Wilderness Under the Earth*

about 300 feet leads into the gigantic pothole which extends upwards for another 150 feet. We three guests and Albert were the only ones who wanted to make a descent, for the next rest was once more to be in the Bivouac hut.

The wire ladders were lowered; Albert was already climbing down, and I got into position to follow him. The header of one 400-foot length of nylon life-line was secured to a karabiner on my sling.

"This nylon is especially good when it's damp," said Fred. "Besides, it is far more elastic than a hemp rope. I once hung free on one and bounced up and down as on a rubber band."

I climbed over the ledge on to the ladder. The height corresponded to a 35-storey skyscraper. Gradually I plunged deeper into the darkness; the light from the lamps above grew dimmer and I was alone. In the pitch darkness of my surroundings the light of my own lamp seemed so bright that it was like being caught in the blinding cone of a searchlight. Rung after rung I descended—there were several hundred—automatically slipping my hands down the supports. Careful! One of the rungs must be broken. When throwing down the ladder it had broken against a rocky spur.

While the upper two-thirds of the ladder still lay flush with the rocky wall, the lower part hung free. Below me I could now clearly see the reflection of Albert's lamp. The ladder caught. "Oo, ooh!" I called at the top of my voice. Communication is usually so bad that it is always a good thing to arrange very definite cries. "Aah" means hand the ladder up. "Ee, eeh" means stop lowering, and "Oo, ooh!" pay out. Fred, who was holding me above, understood, and shook the ladder free from the rock. After a few minutes I was standing beside Albert.

Ivan and Rudolph now followed and we could see a little more of our surroundings. We climbed 660 feet up a great scree slope to Camp IV, the "Misery Camp". Not far from here, in a bedding joint, we found a few glassy stalactite bosses, while the corresponding stalagmites were coated with sand. Retracing our footsteps for a few yards we stood at the fork leading to "The Clay Canyon". This splits into two arms, the west one leading to "The Baron's Shaft" and the east one to "The Rain Shaft". Both come out into the 200-foot "Seven

*Tantalthöhle—the Most Difficult Cave in Europe*

Pots' Hall" into which we tried to peer through the openings of the Pots.

Now we had arrived at our point of return. We had neither the time nor the equipment to descend any deeper, and, moreover, we still wanted to explore a few hitherto unvisited side galleries.

Albert told us of the last great expedition which had taken place a few weeks before. Norbert Zernig from Graz had joined the Salzburg team led by Gustave Abel. On that occasion, ladders were lowered on a line from "The Grand Canyon", and a team remained at the top for seven days in the icy cold of "St. Helena Cathedral" until the advance group returned.

"We descended through 'The Rain Shaft' into 'The Seven Pots' Hall'," said Albert. "The shaft takes its name from the icy showers you receive on the way down. We reached the bottom at midnight and it was time to look for a place to camp. We wasted no time and camped near a pool which was rather like a swamp puddle so we named the spot 'The Water Hole'.

"Next day we broke camp at two o'clock in the afternoon. A tight crawl led us from 'The Stony Lake' to 'The Nosedrip Shaft'. Two more of us stayed behind at its opening. At midnight the remaining four began the descent.

"Now we were in unexplored territory. Terraced steps led to a steeply descending passage which followed a large fault into 'The Windy Shaft'. As we descended between the clay-coated walls, we heard a dull roar. We thought that it must be a waterfall but at the bottom of the pitch we found a clay tunnel facing the wall out of which blew a gusty wind. For some hours we dug with our climbing hammers and the shields of our acetylene lamps but we could not get through. We had to give up. The expedition had lasted 209 hours."

Now we, too, started on our return journey. We climbed the 330-foot ladder to "St. Helena Cathedral" and worked our way through a series of passages, rifts and chambers until we were close to the Bivouac hut.

It was six o'clock in the morning. The two Koppenwallners, Morokutti and I still wanted to explore one of the side galleries but the others returned to the camp.

## *Wilderness Under the Earth*

The side gallery in question led first in an easterly direction, continued with a few bends and finally opened into a chamber with a very small stream flowing in a deeply cut trench, which swelled at one place into a pool about three square yards in area. The water flowed from a rift in the wall, and to the left of this rift the chamber narrowed into a tube blocked with loam.

"Let's dig our way through," suggested Xaver, crawling on ahead with his brother close behind him. Lying on his belly, the leader scooped up the sand while Fred passed it back behind him. After ten minutes we relieved them, for work in a narrow cleft is difficult and after a few minutes you sweat profusely—and moreover you nearly freeze to death while waiting.

Two hours passed while we alternately sweated and froze. Xaver was now ahead but could not be spotted after the allotted ten minutes; there was no answer to our cries. Fred said suspiciously, "I bet he's slipped right through and there'll be no stopping him." Then after another ten minutes we caught sight of his wobbling legs disappearing through a narrow opening. We hurried after him and were soon standing in a long narrow chamber, while away to the right, behind a barrier of rock, a dark patch revealed a new section. We rounded the corner and found ourselves in a big chamber, the far end of which climbed steeply. The water we had already been following cascaded down it, and there was a shaft overhead.

"Let's call it a day," said Fred, stifling a yawn.

Since we were all tired, and it was doubtful whether the steep water pitch could be forced without special equipment, we agreed.

We reached the camp at nine o'clock. Albert and Rudolph left us, because both of them had to be back at work on the following day; whereas Rudolph had had at least three hours' rest, Albert had been on his feet for twenty-nine hours.

Now we were only five and there was plenty of room in the hut. In a few minutes we were fast asleep.

By the time we woke up most of our watches had stopped, for we had slept the clock round. We were ravenous. Bruni cooked

### *Tantalthöhle—the Most Difficult Cave in Europe*

a meal of oatflakes and chocolate, with tea and omelettes as the main course, but since the pan could not be washed between courses because the lack of water, there was a certain sameness about the dishes. Nevertheless, I have seldom eaten a meal with more relish than that one in the camp.

Pleasantly relaxed we lay down once more for a short rest. At last Fred chased us to our feet.

"Our guests will think that we only come to the Tantalthöhle," he said, "to eat and slack."

I wrote my name in the hut log-book. There were very few names in it and they were nearly all repetitions: Gustave Abel, Alfred and Xaver Koppenwallner, Albert Morokutti, Dr. Fritz Oedl Jr., Siegfried Felber, Wilhelm Schaup and Gottfried Rieder. In brief sentences are preserved the most important events of previous trips, and where words were inadequate Xaver had helped with dramatic drawings. Finally, I added my flower patterned coffee mug to the hut's inventory. In this wilderness, it had aroused the greatest admiration and would in future be considered one of the most luxurious chattels of this subterranean shelter.

At two o'clock in the morning we broke camp in excellent fettle, thoroughly rested and well fed. We had lost all sense of time, with no idea whether it was day or night for in caves there is no difference.

On the return journey we still had one exploration to make. Shortly after "The Meander", a way leads in a north-westerly direction. For ten minutes it was a comfortable stroll through the tube-like section which alternates with six-foot high chambers and low places where we had to crawl.

Suddenly we found ourselves at a cross-joint chamber; to the right the floor climbed at first in a gentle slope gradually rising to 60°. Fred immediately began to climb. His figure grew smaller and smaller as he drew away from us and showers of loose flakes rained down on us, forcing us to stand back.

"I got up to about 260 feet," he said on his return, "but then a steep rock face made me turn back." He emptied his pockets. "Plenty of bean ore up there," he reported.

Now we turned to the left and proceeded a few steps along a slightly downhill stretch with a series of forks, but we realized

### *Wilderness Under the Earth*

that with the short time at our disposal we should not do very much good here so we turned back, this time for good, and made for the entrance.

We came out at 22.30 hours. For eighty-five hours we had seen everything by the light of our acetylene lamps, but now in the open air once more we looked up and saw a few cumulus clouds and a starry sky.

## *Chapter Seven*

### “THE HALL OF FANTASY”

A COOL NORTH WIND blew over the Alpine meadows: a thin superficial layer of ice splintered beneath our feet like glass. The sun shone bleakly through the morning mist.

Our little group, the zoologist Dr. Vornatscher, the geologist Dr. Helmut Riedl (then still a student), Dr. Trimmel and his wife Erika, and I had arrived at Weiz from Graz and were now on the way via Leska and Haselbach to Schachen where we were due to meet Hermann Hofer, the explorer of the Katerloch.

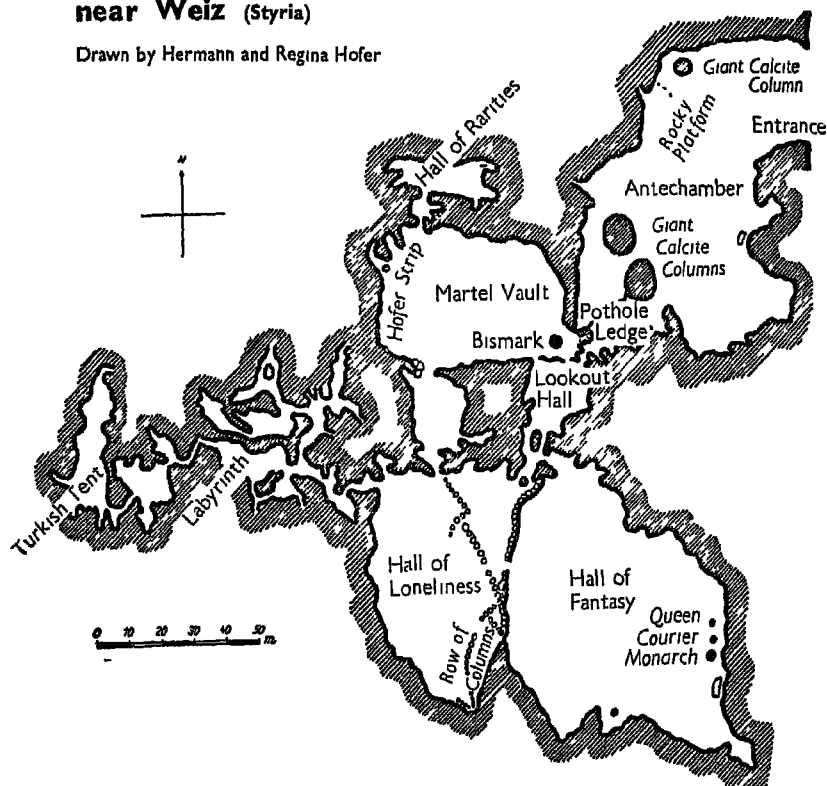
I did not know Hermann Hofer personally but I had heard a great deal about him. His name is closely bound up with the Katerloch and this cave has become his lifework. He arrived for the first time in the neighbourhood of Weiz on his honeymoon and visited the Grasslhöhle. Shortly afterwards he settled in Schachen, rebuilt a path up to the cave and installed a most effective electric lighting system which shows off the stalactites to their best advantage.

The Katerloch lies on the same slope and about half an hour away from the Grasslhöhle. As opposed to the latter, to which an inconspicuous shakehole opening leads, the Katerloch has an imposing entrance 70 feet wide and 40 feet high, into a huge chamber 490 feet broad, leading westwards in a slight decline. This ends at a pitch with a 133-foot drop. As many others had done before him, Hofer descended on a wire ladder to the floor of the pothole and investigated the adjacent “Martel Vault”. Unlike his predecessors, he was struck by a fractured place with stalactite formations on the wall which strengthened his hopes of discovering new sections. Slowly and deliberately he climbed up to an overhang, negotiated it successfully and continued the ascent. A second overhang,



## Plan of the Katerloch near Weiz (Styria)

Drawn by Hermann and Regina Hofer



further success and his efforts were rewarded. At a height of 50 feet, he reached an opening through which he came into a series of chambers. Here was a fairyland which he was the first man ever to see!

That day we were to be shown these newly-discovered sections. Hermann Hofer, a lean sturdy man with a black beard, was expecting us and we set out immediately for the Katerloch. After changing into our caving clothes in the antechamber, we followed the leader into the innermost parts. The cold heavy air had collected there and we began to shiver as we started the descent. We only needed to go down 50 feet, for Hofer had found, inside the cave, an ascending chamber which according to his calculations should lead to a smaller opening near the great pothole. With difficulty he broke through and now we

### *"The Hall of Fantasy"*

could descend without great effort until the roof lifted above our heads. We were now standing in "Lookout Hall" and could peer through a window in the "Martel Vault", whose dripstone decorations appeared indistinctly in the weak light of our lamps.

We reached the next chamber through a low sharply descending passage and when at last I could raise myself from my crawling posture and lift the lamp, the sight took my breath away. An unreal reflection came from a maze of close-packed stalactite columns reaching from the floor to the roof—original calcite formations, reminiscent of a wax figure cabinet displaying strange monsters and conceived by a distorted brain. We reached the heart of the cave system in the spacious "Hall of Fantasy", 394 feet long, 279 feet wide, and between 10 and 59 feet high, consisting of countless rimstone barriers. At every step we took, new marvels awaited us—crystals in dried out water basins, transparent blade-thin curtains, serrated calcite excrescences on stalactites, and thousands of silvery white straws in clusters. We did not know where to look first, to distinguish some detail out of this fantastic tangle. Hofer then led us slowly down the sloping floor of the Hall. Each step had to be taken with the utmost care—to one side, in places, yawned a vertical 130-foot deep pitch and on the other the floor was covered with a mass of tiny formations which it would have been a crime to destroy. Coral formations, small flakes of transparent calcite, layers of embedded bat-bones. We passed down vaulted wallstone-covered corridors into the deeper regions, admiring "The Hall of the Statues" with its dripstone "Monuments"—a gleaming alabaster-white stalagmite, 16 feet high, contrasting with the other bluish calcite formations. Not far away was a 20-foot hollow stalactite which looked ridiculously like a shark strung up by its tail.

We crawled into "The Treasure Chamber", a low, formerly flooded room encircled by a thick, level rim from which sprouted thorny crystallised calcite roses. Now we penetrated the deepest part of "The Hall of Fantasy" where we strode over gigantic piles of fallen stalactites on which new jewels are already being formed. A few rifts in the flowstone roof and rows of broken off stalactites showed that the formation of

## *Wilderness Under the Earth*

these caves had resulted from tectonic displacements. Another proof of this was a broken stalagmite leaning against the wall, out of whose break another stalagmite of the same size had grown, the two of them forming a slanting V.

Hofer had tried to count the stalagmites on the floor. His intention was to include only well-formed stalagmites of a height at least 2 feet and he soon reached a figure of two thousand. These included about two hundred and fifty reaching from the floor to the roof, the largest columns being 60 feet high.

I could read on his face the pride of the discoverer. This was his kingdom. Here he had built a path through the tangle of calcite figures, photographing and measuring them; here he had eaten his sandwiches and lain down to sleep so as not to waste any time on trips to and from the village.

Now he called us around him and asked us to listen. With a piece of wood, he tapped lightly on a few of the stalagmites. In many caves dripstones can be made to ring, but the results are usually dull or leaden-toned. But in "The Hall of Fantasy" in the Katerloch, a veritable miracle of sound was produced. Each of these formations echoed like a heavy bell. Chords rang through the chamber filling the whole space, echoing in all directions in a symphony of bells which no human ear could possibly analyse.

After a snack, Hofer wanted to show us parts of the cave which he opened up in the course of his voyage of discovery before finding the second entrance through "Lookout Hall". Dr. Trimmel and his wife, Riedl and I followed him while Dr. Vornatscher remained behind in "The Hall of Fantasy" hunting for his beloved beetles and cave lice of which he had already made a fine collection.

We slipped through a squeeze into "The Hall of Loneliness". It was like crossing from a well-tended garden into an unfrequented wilderness and actually this particular stretch is very seldom visited. There is no built-up path—we traversed steeply inclined wallstone ledges with several rifts in them where we could take a rest. Stalagmites could here be used as handholds; they were almost like banisters. The formations were rarer here than in "The Hall of Fantasy". It is a gloomy and sinister spot which lives up to its name.

### *"The Hall of Fantasy"*

Next we reached a narrow fissure—Hofer leading us down "The Penitent's Way", followed by Hubert, Erika, myself and finally Riedl. Soon we had to bend our heads and finally crawl forward with our bodies hugging the ground until we reached the spot where the roof lifted—the entrance to "Hofer Hall". A ladder hung down from above and up this Hofer and Hubert soon disappeared, but Erika made heavy weather as she hauled herself up the rungs.

I had to wait below until I received the order to follow as in chimneys like this only one person can climb at a time, for stones are constantly being loosened and can easily injure those below. In confined cave spaces every noise is magnified. The scratching and rubbing, the clatter of the wooden rungs against the rock and the panting of the climbers' rang loudly in my ears. I thought of how Hermann Hofer forced these pitches for the first time, and tried to imagine his sensations upon first entering "The Hall of Fantasy". I am convinced that no seafarer could be happier when reaching some remote, unknown and wonderful landfall than a cave explorer who has been lucky enough to make such a discovery.

I waited a long time. No cry rang out. The rustle of the climbers fell silent and the ladder had stopped dancing.

I called up. . . . No reply. I thought I heard a stifled sob. Nothing remained but to climb up.

The chimney was unpleasantly narrow and the climb was less an overcoming of gravity than the forcing of a passage between rough, jagged rocky walls where it was difficult to bend the knees and to see where to place a foot. The ladder gave hardly any support since there was usually not enough room to get a firm hold in the rungs even when they could be felt. After a few feet I was in a muck sweat.

A shadow appeared above me—Erika. She had stuck half-way up the pitch, too exhausted to move. Luckily I discovered a nearby ledge in a stretch of sloping wall and guided her to it so that she could recover, and there she cowered on the ledge and buried her face in her hands.

At this moment Hubert's voice rang out from above. I asked him to come down and give me a hand.

On occasions we all succumb to these moments of absolute

## *Wilderness Under the Earth*

despair when the last spark of self-confidence dies and we are a prey to sheer terror. I once experienced this when hanging in an ice fall half-way up the Ötscher Pothole; my acetylene lamp had long since gone out—I saw that the ladder had stuck and that I could climb neither up nor down. And again, when I wriggled painfully through a squeeze in one of the smaller caves in Upper Franconia; having forced my way in without much difficulty I suddenly realized that my legs were irretrievably stuck.

Hubert reached our ledge and relieved me. I climbed up after Hofer, and Riedl soon appeared. There was then a second wire ladder to negotiate, and after crossing "Hofer Hall" we came at last to the window in "The Martel Vault" through which Hermann Hofer had come when he first entered the section which now lay behind us.

Hofer pointed to a few holes on the rock face opposite. He had managed to reach them by traversing the wall and had discovered new chambers with magnificent, undamaged stalactites. He told us that one day he would show us this part of the cave system.

We returned slowly by the same path—the path along which his wife Regina had brought him his food when he made his intrepid forays from "The Hall of Fantasy". Times without number she made the complete journey alone and back, before a safe path had been built and when there were no ladders hanging in the pitches.

In the meantime Erika had recovered and was waiting for us with her husband in "The Hall of Loneliness". Without incident, we reached "The Hall of Fantasy", where Dr. Vornatscher was still crouching over the rimstone basins, fishing for primitive insects. He joined us and we were soon back at the squeeze leading to "Lookout Hall", and cast a last glance at the stalagmite garden, the curtains and the glittering crystals with their infinite variety while the inner parts disappeared once more into the darkness out of which we had temporarily withdrawn them with our artificial lights.

\* \* \* \* \*

The vegetation of caves consists of calcite or other mineral formations—no organic vegetation as in our plant world but a

### *"The Hall of Fantasy"*

mineral one, but no less capable of growth and wealth of form. Not everywhere does it luxuriate and often only sparse formations are found, modest roof bosses and calcite buttons like coral, but in places it flourishes and is capable of filling and closing cave chambers as in the labyrinth of the Schönstein Cave in Upper Franconia, in the Bärenhöhle at Erpfinger in Swabia, or in the Katerloch at Weiz in Styria. At the same time, calcite formation is the opponent of cave building solution. This contrast goes still further. In a certain respect the calcite formation is actually the opposite process to the solution of limestone by water containing carbonic acid; in other words the secretion of the dissolved fragments from solutions subjected to gaseous carbon dioxide—sometimes incorrectly called carbonic acid—the same gas that bubbles from beer and mineral water. In these drinks, too, it is dissolved; it has the capacity of dissolving in water the more freely when the pressure is increased. When the pressure is removed on opening the bottle, a great part, though not all, of the carbon dioxide is released; a certain percentage remains in the drink and gives it that familiar, prickling acid taste. The acid characteristics of carbon dioxide also play an important part in the percolating of rain water through limestone. We have already seen how the rain collects carbonic acid out of the air, thus acquiring the properties of acid which enable it to dissolve the lime.

Just as decreased pressure releases carbon dioxide from the solution, so in certain circumstances the dissolved lime separates once more from the solutions. For example, this is invariably the case when vapour is present, for the solid particles must naturally remain behind while the solution is transformed to steam in the gaseous phase.

This is also the case—and to a far greater extent—when the physical adjustment between the carbon dioxide concentration of the carbonate solution and that of the air in the cave takes place. Professor Alfred Bögli, head of the scientific research in the largest European cave, the Hölloch in Switzerland, was the first to recognize this and furnish a proof, but it is a question of complicated physical processes which lie beyond the scope of this book. We must be content to know that the requirements for separation from lime are often fulfilled in caves; the

## *Wilderness Under the Earth*

results are the amazing masses of calcite formation in many caves, and not only is the quantity of these excretions remarkable but also the strange forms which they take.

What induces the great wealth of calcite forms, from the smooth wallstone to segmented dripstone columns?

The most common form is the wallstone. This is produced by the slow trickling of lime solutions down the cave walls. They are therefore covered with a layer of calcite which would be smooth were there no more or less strongly defined irregularities in the rock surface, although, as the coating becomes thicker, these convex or concave features gradually disappear. This type of calcite formation also occurs on sloping parts of the floor.

The scene looks quite different when no inclined surface is there to allow trickling and parts of the rock overhang, for in this case there is usually a dripping of the solution. The drop of water hangs for a certain time, varying from seconds to minutes, on some roof projection before it falls. The calcite deposit begins at the spot where it is attached to the rock. A paper-thin crystal ring remains behind but soon the next drop forms, until it is heavy enough to fall; this, too, leaves a ring behind which thus increases slowly into a tube-like formation into the interior of which the solution continues to flow. The hollow stalactite column is one of the most fragile treasures of the caves; transparent and brittle as glass it sometimes reaches a length of several feet. It is often found isolated and only very rarely in clusters. In order to find these columns of "straw" stalactites it is necessary to select rarely frequented caves, for they are apt to break off at the slightest movement. For this reason alone they are a rare and impressive sight. The most beautiful I ever found were in a cleft in a little known pothole near Weidensee in the Franconian Jura which I visited in 1952 for the first time, with my comrade Willi Zaunik. Imagine our delight when, after a difficult slide through a low horizontal cleft, we discovered a snow-white section, 50 feet long, with a vertical fissure adorned inside with hundreds of these beautiful tubes.

The calcite tube or straw is the embryo state of the roof boss or stalactites as they are called. The hollow centre of the tube

### *"The Hall of Fantasy"*

narrows in time as a result of the solution flowing through it; then it begins to run down on the outside and the thickness increases. In this way monster stalactites are formed like "The Giant" in the Lur Grotto which is 42 feet long and 29 feet in circumference.

Hand in hand with the roof bosses grow their floor counterparts or stalagmites. The drops falling from above splash on to the floor, spreading out over a large surface thus offering a wide area for the air currents to attack and, as a result, having a better opportunity to cancel out the concentration of carbon dioxide or evaporation. The stalagmites as a rule usually grow faster and broader. As is to be expected, the hollow straw of the stalactite, by which the latter can be identified when it has been broken off, is missing. Naturally dripstones can also occur on ledges on to which water drops, sometimes becoming cascades on the wall or free-hanging curtains.

On even floor surfaces another type of calcite formation occurs—the rimstone basin or gour. These are pools of water or, to be more accurate, puddles of chalk solution, which naturally evaporate, in particular round the rims. Thus, in time, a shallow container is formed round the water which has collected. The Central Massif in the South of France is the region richest in dripstone formations; when I first visited the galleries of some of the caves there I was speechless before the forest of stalactites. It is impossible to say which of these famous caves possesses the greatest objects of interest. Even if we reject all the smaller caves, five remain which are of equal merit: Lacave, Padirac, Dargilan, Aven d'Armand and Aven d'Orgnac. Each of these has its specialities and yet their common feature is the stalagmite columnar formations which often tower to over 60 feet. They stand close together as though they were fighting for room, and it often happens that one will grow sideways out of another. The picture is even more bewildering since these dripstones are not smooth columns but clustered, segmented, or with fan-shaped lobes, creating a vague resemblance to palm trunks. It is a great pity that these natural phenomena lie in one of the most desolate corners of Europe, for they are well worth the trouble of a visit.

An unusual type of calcite formation is the coral formation



## *Wilderness Under the Earth*

which is usually found in regions poor in dripstone. They are protuberances not unlike moss or lichen and their origin has not been satisfactorily explained. Bacteria related to the blue algae family have been found in many of these diminutive forms and it must therefore be presumed that organic lime excretion is largely responsible for their formation. I have, however, frequently found types of button calcite which were certainly of a different origin. In the Witzen cave near Muggendorf in Upper Franconia, for example, I found a wall covered with fine crystal needles, and in places these had weathered and assumed the typical aspect of button calcite.

Atmospheric conditions naturally effect the décor of caves, and sometimes the roofs and walls are thickly covered with brown or greyish layers, in many cases the results of weathering.

Another type of material to be found in caves of which we do not know precisely whether it was produced by weathering or should be regarded as plastically excreted calcite is mountain milk. Although it often looks and even feels dry, it exudes water when firmly pressed between the fingers. Of the caves which I have personally visited the richest in mountain milk is the Kroatenhöhle on the Lueg Pass near Salzburg, for here, in the innermost sections, everything is covered with thick layers of it. Dr. Trimmel, Corbel and I had the greatest difficulty in climbing the rising terraces since they seemed to be smeared with saddle soap. When I wanted to rest near a thick 10-foot tall stalagmite column, my forearm sank into a whitish mass—I think the whole formation was made of mountain milk—and when we left we looked as if we had been rolling about in wet flour.

The chemical substance of calcite is carbonate of calcium—the same material of which most of the pillars are formed. It excretes at first in fine crystals, later a recrystallization ensues so that the dripstones are sometimes merely gigantic crystals.

Pure calcite is colourless and transparent, but traces of foreign substances such as iron and manganese salts give it vivid colours. In the Kohler and the Ameiskogel caves in the Ötscher region in Lower Austria I have come across orange stalactites and blood red patches of calcite which at first I mistook for bloodstains; the Macocha cave in Czechoslovakia

### *"The Hall of Fantasy"*

is well-known for the brilliant colours of its dripstones, and pale green and sky blue calcite draperies were found in the Hölloch in Switzerland.

From static water the carbonate often excretes as a crystal. The most beautiful decoration is to be found in caves which at one time were flooded and in which, therefore, roofs, walls and floors are covered with a sparkling layer of crystal. I came across this phenomenon for the first time in the Little Peggau cave, and later I occasionally discovered similar caverns. One of the most spectacular is the crystal chamber of the Attendorn dripstone cave in Sauerland—where flooding with chalk solution followed when the cave was already full of stalactites. Each floor boss is covered with thick clusters of crystal and the whole floor is a single glittering carpet.

The most majestic crystal adornment, however, is undoubtedly in the Tantalhöhle near Salzburg. A day's march from the entrance, the chamber is reached through stretches of tunnel which are ablaze with a rare type of calcium carbonate crystals that have assumed the shape of flowers which seem to be growing out of the rocky walls.

A great deal has already been written about the age of dripstones. There are cases in which the growth of stalactite tubes can be measured—they increase by a few millimetres each year. But it is certain that the process of growth normally takes place at an incomparably slower speed. Attempts have often been made to calculate the age of a stalactite by postulating a certain yearly increase in length, and reckoning the number of years by the height. Taking one millimetre growth in a year, we reach a figure of a thousand years for a stalagmite 3 feet high. This method, however, is not at all reliable since long periods of time could elapse in which there was no growth. There are many stalactites which we know must have preserved their form and breadth unchanged for at least 20,000 years and perhaps longer—a fact which clearly demonstrates the fallibility of such time calculations.

## *Chapter Eight*

### GREEN LIMESTONE CAVES

IN GERMANY THERE are four great cave regions which differ greatly from the sparse Yugoslavian karst and the Austrian limestone Alps: the Harz with the Kyffhäuser range, Sauerland, and the Swabian Franconian Jura. These fall in the category of green limestone. By this term we understand subterranean limestone regions which are barely visible from outside, since a luxuriant vegetation conceals the true character of the rocks below.

The oldest cave in the Harz Mountains open to visitors is the Baumannshöhle in Rübeland (Northern Harz) upon which the miner Friedrich Baumann stumbled in the year 1536, when looking for ore. Shortly after its discovery it became a show cave.

The largest chamber of the Baumann cave, "The Goethe Hall", owes its name to a visit paid to it by the great German humanist on December 1 and 2, 1777. Goethe was much impressed by the magic of this subterranean world of drip-stones. With Goethe, the Baumannshöhle was visited for the first time by a representative of the Age of Reason, by a man with a highly developed feeling for nature who did not see the world as split up into single curiosities, but sought to classify it as a whole. In a letter to Frau von Stein, he has given us his impressions upon entering the cave: "I wish that you could have seen in a mirror my childish delight. Is there anything more exciting than nature? How to-day I sat on a cliff—you should have seen it—where neither gods nor men would have looked for me."

On the opposite slope of the valley above the Bode torrent, still in the Rübeland district, lies the Hermannshöhle, which was first discovered by a road building gang in 1866. Seven

### *Green Limestone Caves*

years later Hermann Grottrian, after whom the cave is named, began a thorough survey of it. In 1924 speleologists from Nordhausen continued his work and year after year enlarged the network of the upper stories. The last 400 feet were not discovered until 1952, when cavers, led by Friedrich Schuster, climbed from "The Corkscrew Grotto" 26 feet up a difficult chimney into a shaft and thence into a new storey, "The Ostklüfte".

The visitor to the built-up section has no idea how far the cave stretches into the mountain. Here in this labyrinth, far away from the guided path, is a system of tunnels running at several levels, the century-long work of water erosion on rock. The Hermann Cave is 2,300 yards long and is therefore the largest of the Rübeland caves.

A forest fire in the year 1672 led to the discovery of the third largest Rübeland cave, the Bielshöhle. The entrance lay high up in the crags of the Bielstein range, concealed by thick undergrowth and was not discovered until this was burnt to the ground. The cave is a system of galleries, tubes, chimneys and pots which follow the joints and bedding planes, at different levels.

The largest gypsum cave in Germany is the "Heimkehle" on the Zechstein slope of the "Old Stolberg" in the Tyra valley—a sequence of halls, natural tunnels and vaulted chambers. In the last months of the Second World War, the armament industry commandeered them. Workshops were erected in the centre section; two of the cave's best features—the lakes in the large and small vaults—were filled in and a concrete floor laid over the floor of the cave. At the end of the war, the installations were removed and all that remained was a dreary tangle of ironwork, clinker and rubble. The visitor to-day will see no traces of this period, for the cave has resumed its pre-war aspect, except that the two lakes have disappeared and have been replaced by natural rock paving. Two new sections have recently been opened to visitors, "The Hercynia Hall" and the "Grabenkluff" with particularly well-formed calcite-covered roofs and walls. The visitor is as impressed as ever by the remaining natural marvels in the cave—the ruffled surface of the shimmering blue-green "Heimen Lake" which, as the result

## *Wilderness Under the Earth*

of light streaming through a natural arch 71 feet higher, throws charming reflections on the roof; the 150-yard long, 10- to 16-yard wide, 20- to 26-foot high "Giant's Tunnel", the deep dark "Tyra Lake" and, at "The Great Cathedral", a 196-foot high pyramidal vault. We should not forget the men whom we should thank for this experience, the Harz pioneer spelcologist Dr. Friedrich Stolberg and his Nordhäusern friends who are still just as active as when they, together with the Rübeland cave guides, opened up the cave after the First World War.

West of Solbad Frankenhausen lies the Barbarossa Cave, a unique system which has the peculiar characteristics of gypsum to thank for its main decoration. Here in the Harz it was first discovered that gypsum was a limestone-forming rock.

Gypsum is a loose chemical composition of calcium sulphate and water. When heated to about 180° C. the water evaporates, leaving nothing but a dull white powder. It is, of course, used mainly in building, but can be used for a host of other purposes—for example, plaster casts and plaster of Paris. It greedily absorbs water until it becomes solid gypsum once more, but the strangest feature is that in the process of amalgamation it increases in volume.

The gypsum in its desiccated form is found in its natural condition in the Permian formation of the Barbarossa cave. When water percolates through the joints and fissures from the surface, expansion takes place, the crevices narrow and become closed, and the water thus bars its own passage. This expanding property of desiccated gypsum has another effect: the damp air settling on the cave walls causes an expansion of the rock surfaces; fine layers flake from the wall, curl and crinkle, bend and roll themselves up into fingers or furry ruffles. The typical form of this cave wall drapery is to be found in the names of the various chambers: "The Cloudy Sky", "The Swiss Landscape", "The Bacon Larder", and "The Tanner's Yard".

This cave houses further crystal treasures: wavy, spiral bands of gypsum known as "serpent gypsum"; bundles of radiating gypsum needles, paper-thin skins on calm patches of water—forms which in their smallest details reveal a particular cave

### *Green Limestone Caves*

character. Each cave has its own typical world of forms, and its own story which is never repeated anywhere else.

The Sauerland owes its wealth in caves to a limestone strata running from the Wuppertal in an arc via Hagen and Altena into the Hönnetal to outcrop in several isolated masses: the hills of Warstein, Attendorn and Bergisch-Gladbach.

As in the case of the green limestone, the type here is primarily the hollow cave enlarged by water and rich in dripstone. As is invariably the case with caves containing stalactites, they have become a tourist attraction—this is the summer holiday resort of the Rhineland Westphalian industrial area—and these subterranean marvels of nature are well exploited as objects of interest. I was torn between enthusiasm and sorrow in the Sauerland show caves—enthusiasm for the variety of the calcite formations, and sorrow at the great changes and destruction that had been caused by opening up the caves to the public.

The oldest show cave is the Dechenhöhle at Letmathe, which was discovered in 1868 on the building of the railway, and is still the property of the railway company. With a uniformed official as guide, the visitor is led through a series of picturesque dripstone chambers whose names attest vaguely to their aspect: "The King's Hall", "The Organ Grotto", "The Palm Grotto", and "The Wolf's Gorge". The latter chamber lies in the second part of the cave which crosses a rock collapse zone and is sinister compared with the first rather friendly part of the system. In the final galleries, thickened, round stalactites, affected by a globular growth, hang from the roof, and the visitor has the impression of having entered a vegetable garden full of mangel-wurzels and radishes.

The Attendorn dripstone cave, discovered in 1907, became a serious competitor to the Dechenhöhle. Its wealth in dripstone is unsurpassed, for at least three types of calcite formation exist: thick layers arch over debris, multi-coloured younger stalagmites rise from the floor and paper-thin striped calcite curtains hang down from the roof. The splendour in some of the chambers, which were once filled with water, is amazing. Thick layers of glittering crystal have formed on the walls and even

### *Wilderness Under the Earth*

the stalagmites are covered with them. On some of them, the knee-height layer is so thick that they look like tables; on a comparatively thin stem is a solid lump of clumsy carbonate stars, the formation ending with a flat surface, obviously at the height of an earlier water-level. It is a great pity that a systematic check of the strata cannot be undertaken, and an even greater shame that in this cave scientific interests have been waived in favour of the tourist trade.

A highly interesting region is the limestone mass east of Sundwig on whose plateau lies the famous "Rocky Sea", a depression of about half a square mile strewn with limestone blocks as large as houses. Its borders are also wild and ravaged and at every step rifts are found leading down into the bowels of the earth. Much to the surprise of a few visitors, I slipped down into one of these holes and, at about 30 feet below the surface, discovered a network of galleries and tight crawls in some of which a pale gleam of light trickled from above. Occasionally I caught sight of a few heads peering inquisitively over the edges of the rifts.

Below I found no traces of humans, and these old water-courses give an impression of emptiness and desertion. Indications can be seen of the rivulets which abraded deep grooves in the walls; the floor is covered with dirty yellow clay and in places swallets lead into the depths, outlets for the water in its quest for deeper levels. I found no calcite.

I am prepared to believe the stories of the natives that there is a communication between the two caves which enter the mountain at valley level—the Heinrich and "The Prince's Caves".

When the amiable proprietor of the Heinrichshöhle showed me over his treasure, he mentioned the adjacent dangerous Prinzenhöhle into which two students had recently ventured with inadequate lighting equipment. They had to make the return trip in the dark, and one of them fell to his death, but his companion escaped with a broken finger.

Later I visited this cave with a young local. The main gallery is 270 yards long and was used during the war as an air raid shelter, so anything worth seeing had long since been destroyed. The inner regions, however, which can only be reached by a difficult climb up dripstone chimneys, are all the

### *Green Limestone Caves*

more beautiful. These stretches are very narrow. We forced our way along damp flowstone walls, crept at full length through tubes, and clambered up the steep pitches using dripstone bosses as a support.

This free climbing in the maze of clefts in "The Prince's Cave" was a joy. The dripstone formations appeared one by one in the light of our lamp. How pathetic are the imaginative names given to the figures in electrically lighted caves compared with the beings and shapes in these virtually unexplored realms of the night! Here we needed no romantic explanations from a guide, no gay lighting, and no little clay dwarfs. Here the phantasmagorical faces of the dripstone figures came to life in the reflection of our lamps; here the stunted arms of the stalagmites loomed in serried ranks out of the darkness as the light fell upon them. And each foot of soil had to be conquered and in each large chamber I felt as though I had just won a major battle.

Our goal was an unnamed dripstone hall—the roof covered with calcite blossoms and the floor with massive clubs. A deep rift yawned at our feet; the rocky floor on which we stood was cleft and scarred, consisting perhaps of fallen boulders which had got wedged together in this big space. Here, too, there would have been plenty to explore but unfortunately I had no time; I was delighted, however, that immense treasures still remained to be discovered.

I had further proof of this from a report of a newly discovered dripstone cave on the Hohen Liet, south-east of Warstein. A typical karst phenomenon corroborated the theory that an extensive cave system lay hidden beneath the Warstein limestone mass: a stream disappeared on one side into a cleft and emerged on the other side a mile away to the north-west. A test with fluorescein proved the connection. It was impossible to force a passage from either entrance into this system but access to the older, higher level was achieved by blasting. After a few yards of exhausting crawling, the explorers reached a network of fissures through which they attained the next stage by a 30-foot pitch. A second labyrinth of passages and fissures and once more they were faced with a 30-foot deep pitch. Below, a sump appeared to forbid any further advance, but the men



## *Wilderness Under the Earth*

plunged into the water and wading up to their necks, with their heads just beneath the roof, forced an entrance to a new section. Professor Franz Lotze described the cave as a fairyland. The stalactites reached a length of 10 feet, the calcite draperies and the bosses on the floor were snow-white. Eighty-eight feet below the entrance level, he discovered the subterranean waterbed; it was no gay sparkling brook, as on the surface, but a slow-moving, dignified waterway.

The Klutert Cave in the Ennepe valley is exceptional for various reasons. With its 5,600 yards of galleries, it is not only the largest cave in the Sauerland but in the whole of Germany. It has an extraordinarily mild climate and a constant temperature of 10° C. This is perhaps the reason why a cave beast is to be found here which exists nowhere else—the Klutert crayfish, an 11-millimetre long, colourless species.

During the bombing attacks in the last years of the Second World War, the population used the cave as an air raid shelter, and people suffering with asthma found a surprising improvement in their health. After the war the climatic conditions in the cave were carefully investigated; the results strengthened belief in a cure and since then invalids from all over the world visit the Klutert Cave Sanatorium.

This cave is still in a comparatively young stage. In a network of vertical joints are bedding planes which are being enlarged by the water into tunnel ways. A circular tour has been made accessible. In some of the side galleries which I visited with a man who knew the cave, I had to wade through pools of water and force a number of tight crawls. In several places there were streams which have ponded up into lakes.

In addition to these show caves others exist in the Sauerland which are famous for their prehistoric finds—the Balverhöhle which furnished over 50,000 artifacts—fashioned bones and flints; the Leichenhöhle where forty human skeletons dating from the Bronze Age were found, and the famous Feldhof Cave in which one of our ancestors in the evolutionary stage (*Homo neandertalensis*) was discovered.

The Swabian Albs with their many villages and fortified churches also possesses subterranean treasures, as is to be

### *Green Limestone Caves*

expected in a limestone region. The caves are not particularly extensive but are rich in natural beauty and are well worth studying.

The largest is an active water cave—the Falkenstein Cave north-east of Urach. It can only be visited in the dry season, and then with difficulty, for there are several stretches of water to be crossed. The great obstacle is a siphon, 510 yards from the entrance; nevertheless cavers have managed so far to penetrate 2,950 yards into the interior.

Many dripstone caves in the Swabian Jura have been opened to the public—the Charlottenhöhle near Hürben with its "Bear Crawl", a narrow passage, which has been rubbed smooth by prehistoric bears forcing their way through it; the Nebelhöhle once used by the banished Duke Ulrich of Württemberg as a hiding place; the Friedrichshöhle at Wimsen, a water cave which the tourist visits in a canoe; and I must mention the amazing technical feats accomplished by the members of the Laichingen Caving Group under the auspices of Helmut Frank who opened up a completely vertical shaft to the public—the Laichingen Pothole, which consists of several potholes joined together by galleries. The main pitch, in which the visitor descends over more than a hundred steps from platform to platform, ends in a roomy chamber with a towering boulder fall and a host of horizontal grooves showing earlier water levels.

The most valuable find was the discovery in 1834 of the famous Karlshöhle near Erpfingen. Karl Bez, one of the guides, one day found a continuation rich in magnificent dripstone. Bez himself, a man of about thirty-five, led me into the new section. A few years ago the broken belt of a sawing machine crushed one of his legs and there was a fear that amputation would be necessary, but fortunately the leg was saved and to-day only a slight limp recalls this accident. In spite of his disability he crossed the uneven flowstone floor easily, and opened an iron gate which bars the way to this dripstone paradise. Tall slender pillars, fashioned like palm trunks with round gleaming tops, tower to the roof. On the walls a light brown layer of calcite follows the unevenness of the rock face forming regular waves, and among an infinite variety of carbonate of

### *Wilderness Under the Earth*

calcium formations were found the remains of bears, the primitive inhabitants of this cave: jawbones, ribs, claws and teeth. In memory of these bones the hall was christened "The Bear Cave", by which name the whole system is now known.

Karl Bez told me how he had discovered it:

"I had pondered for a long time as to whether the Karls-hohle had a still undiscovered continuation. During my tours as guide, I kept on looking for some possible entrance, and then one day in the large hall I noticed two bats fluttering near the roof. One of them suddenly disappeared.

"After this I kept my eyes open even more and about a fortnight later I saw my two bats again. They, too, disappeared, but this time I spotted the opening through which they had flown.

"On December 27, 1949, seven of us crept into the cave. Our first attempt was to be kept a secret. We climbed up the flowstone wall on a ladder. The opening was about two and a half feet high and I forced an entry without difficulty. There was an immediate surprise in store for me—the skeleton of a bear lay in my path. I fetched some more light and crawled forward beneath a flowstone bridge. When at last I could stand up, a mighty chamber lay before me. Overhead was a chirping and twittering from scores of bats which for the first time had been disturbed by man.

"This was the beginning of a series of discoveries. The path led further into a dripstone fairyland—a mass of dripstone formations, series of rimstone basins and, yet again, the remains of long since extinct cave animals."

The Franconian Jura is the highest feature of the terraced Swabian-Franconian highlands between the Keuper terrace of the Steiger Forest and the Palcolithic mass of the Fichtelgebirge. Anyone familiar with the Istrian-Dalmation karst or the Alpine limestone will be struck by the prettiness of the Franconian landscape. The gently undulating fields and meadows of the plateau, the fertile valley soil and the beech-covered slopes do not in the least give the impression that this is a limestone zone. Nevertheless, this region is genuine karst with its dolines—the crater-like depressions above collapsed caves, from which

### *Green Limestone Caves*

rain water or melted snow are absorbed through joints and tubes—its swallets, potholes and the usual cave forms, although everything is on a small scale. The hundreds of square miles of great karst basins or the *poljes* of the Jugoslavian karst, are replaced by shallow cauldron-like valleys, and the vegetation emerging from the dolomite mounds are more in the nature of an adornment than a key to the character of the landscape.

The caves give the same impression as the countryside on the surface. Most of them are definitely smaller than the classical cave systems: the feeling of timeless immensity is lacking here and yet they are grotesquely beautiful. Roofs and walls are often entirely covered by a tangle of stalactites, the mineral equivalent of the plant world, which is often lacking in the Alpine limestone. While the gentle slopes and populous hills make the climb a pleasant stroll, the small size of the caves does not make it easy for the visitor, nevertheless he does not have to reckon with hours of climbing, and is spared ladder descents of several hundred feet. Although it is unwise to go alone, small groups of two or three persons for mutual aid are quite sufficient; which is an unusually small number for a caving party.

The Franconian Albs can be called the "Land of the Thousand Caves" for, with its 1,024 caverns, it is the richest caving region in the whole of Germany. Strange to relate there are not so many show places as in the other German limestone regions. The few that do exist, however, are no disappointment and all have something remarkable to offer.

In the first place I must mention the Pottenstein Teufelshöhle which has been made accessible by the use of the most modern mining techniques. Groups of a hundred and more people can wander along perfectly dry paths through grottoes which give them the impression of having strayed into a garden full of curious plants with rare lichens hanging down from the walls.

To save the visitors any unnecessary effort the floors of certain chambers have been levelled and given a tarred surface, and in an isolated section there is a subterranean sanatorium, the last resort of many invalids.

One of the oldest known caves is the Förstershöhle near

## *Wilderness Under the Earth*

Waischenfeld. In the old days the big dripstone chambers could only be reached by an arduous climb up a chimney, but to-day an artificially built path leads to the main hall whence people can go in several directions. That the caves still afford opportunities for new discovery was proved by Willi Zaunik, who, after working his way through a low clay and water-filled tunnel, came upon two beautiful new dripstone chambers.

The largest cave in the Franconian Jura is "The Maximilian Grotto" near Lake Krotten, which is well administered by Johann Dittmann. In five storeys, it reaches to 220 feet below the surface. Willy Zaunik and I had an opportunity of exploring the cave and visiting the sections not covered by the guides. We took full advantage of this, forcing our way through low-roofed boulder chambers, climbing into clefts, through which we could occasionally see the lamps of the visitors below appearing and disappearing. This cave is rich in dripstone, and one of its halls contains "The Iceberg", Germany's largest stalagmite. By its fairy-like lighting effects the "Peter Leissner Vault" furnishes a surprise: on fine days the sunlight streams down into the bowels of the earth through a hole in the roof.

The neighbourhood of Streitberg is a focal point for caves. One of these dispersed cave regions lies high up on the edge of a plateau. Here in many places the limestone crags emerge from the vegetation and in one of the lower rock faces lies the extensive system of the Schönstein and Brunnstein Caves. A glance at the plan will show the uniqueness of two perpendicular superimposed systems for the ramifications have turned the caves into an immense labyrinth. Anyone who has visited this maze of small and sometimes blind passages will easily believe that, not long ago, two girls sat for three days a few yards from the entrance unable to find their way out of the caves, which they had rashly visited equipped only with a box of matches.

The Schönstein Cave was often the goal of my travels, and on one occasion the mining-engineer Willy Zaunik, one of the men most familiar with the underworld of the Franconian Alps, had been asked by a newly appointed Streitberg forester to show him the Schönstein Cave. We decided to make this an opportunity for visiting certain regions which so far we had

### *Green Limestone Caves*

scarcely explored. When the forester left at seven o'clock in the evening, Zaunik and I remained behind.

At first we took some photographs and then decided to penetrate the clefts beyond "The Paradise Hall". Perhaps we should be lucky enough to open up new sections as the well-known Salzburg cavers Robert and Fritz Oedl had done with Poldi Fürich and Elliot Barton, who sometime later disappeared in China. Thanks to their new discoveries, the known area of the cave had been nearly doubled, although they had never been lucky enough to reach one of the most important goals—the communication with the neighbouring Brunnstein Cave—in spite of trying a smoke test.

Through an insignificant cleft we entered "The Great Hall" from which, by climbing over stalagmites, a man could still advance a few steps until, bearing right from "The Neischl Fissure", he had to do a flat crawl in the direction of "The Cross Fissure". In a low-roofed chamber, the stretch now forked: the left branch led into the rear labyrinth while the right communicated with the clay chambers. Here once more it was a tight squeeze to get through the narrow, low galleries filled with yellowish slime. It is hardly possible to describe the relief a man feels when he finally slips into "The Paradise Hall", can stretch himself and cast a glance at his surroundings as they emerge out of the darkness. Here the narrow passages broaden out into a spacious chamber and the stalagmites are no longer an unpleasant obstacle on his path but a welcome decoration, particularly round the edges of the hall where the pillars stand close together and are sometimes joined. This is the only part of the innermost cave where it is comfortable to walk and the variety of formations can be seen at leisure.

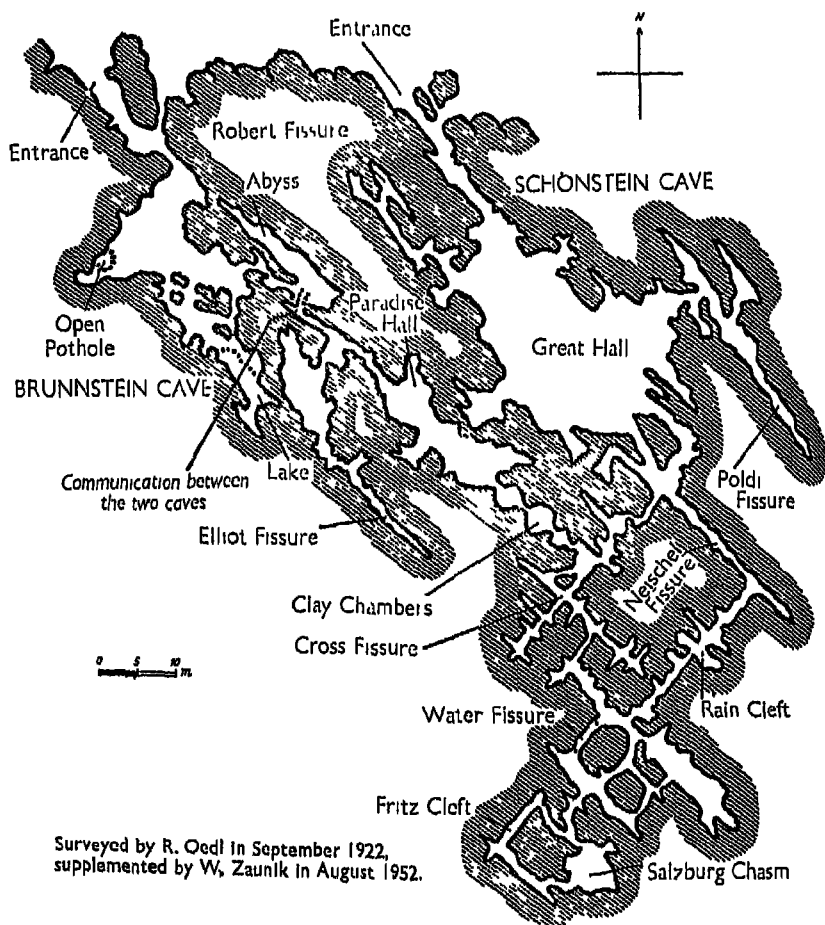
We had often visited this Hall before, so without much delay we crossed it and were soon at the farther end. Zaunik crawled on ahead of me into a horizontal passage and I followed on hands and knees, casting an occasional backward glance so as not to lose my bearings. The place was so thick set with stalagmites that we had to wriggle through like snakes.

Zaunik came to a halt. From previous experience I knew that there was a vertical pitch here in which we had to descend about 16 feet. Willy tried at first to force a passage feet first, but then

## *Wilderness Under the Earth*

he turned over, the upper part of his body disappeared, and soon only his legs were wagging ahead of me. I heard him cry, "It's best head first."

### **Ground Plan of the Schönstein Cave**



I slid forward without hesitation. The abyss yawned black ahead of me. My hand holding the lamp was still behind me and I brought it cautiously forward past my body to light up the rift. It proved of little use and I had to rely mainly on my

### *Green Limestone Caves*

sense of touch. Suddenly I noticed Zaunik's lamp ahead of me and I realized he had not gone down the cleft as on our previous trips but had reached a straight continuation at the same level as our opening, whereas the lower way turned off sharply to the left. I now had to cross the gap. I still could not reach the rocks on the opposite side, so I thrust myself forward a little, until the lower part of my body was wedged in the hole; below was darkness. This was still no good and I had to go still further. Finally, with splayed legs—as a result of my cramped position they began to tremble—I fished for a stalactite boss hanging free over the abyss. I managed to get a hold and slipped far enough forward to draw one foot out of the opening and to venture a step over the abyss. After that it was child's play.

We were now in an uncharted region. Between the narrowing walls of the cleft, covered with bulgy calcite growths from which the water dripped, we wriggled forward, more lying than walking. The floorstone echoed hollow like a drum beneath our hob-nailed boots. We slipped down a step and Zaunik pointed to a spot ahead of him. "Look, a salamander," he cried.

Peering over his shoulder I could observe the black and yellow striped beast, which, frightened by our noise, beat a retreat and was swallowed up in the darkness.

"There must be a second exit here."

"I think we can take that for granted," replied Zaunik, "otherwise, how did the salamander get in here? Certainly not by the way we came."

I agreed with him. We were filled with a pleasant sense of anticipation. We advanced at a greater speed and then, to our great disappointment, the rift turned out to be a blind alley. We illuminated our surroundings as best we could and soon found a hole at floor level running horizontally away to the right. Zaunik forced himself inside and I followed close on his heels; in places we could lie side by side. A clay roof arched slightly above our heads, leaving a small hole free—perhaps 8 inches wide but only 2 inches high. Through this opening the wind rushed at us in powerful gusts. We tried in vain to light it up but we could see nothing.



## *Wilderness Under the Earth*

"That hole seems to lead directly out into the open," said Zaunik, beginning to chip away at the clay with his hammer, but this looked easier than it was for the layer was extremely hard and there was no room to excavate. It was more a scraping and a scratching than a hammering, and for more than an hour and a half we took it in turns to bang at the clay. As soon as the muscles of one refused, the other took his place. Slowly the material broke up and we made a discovery which seemed to corroborate our theory: beneath the top layer of clay appeared a second which was no longer so tough, but was filled with small stones and other debris. On closer inspection they turned out to be black lumps which we could powder between our fingers—pieces of charcoal. So, thousands of years ago, a fire had once been lit here; prehistoric men had roasted their meat and warmed themselves by its flames.

The hole was now wide enough for me to stick my arm through. The wind blew keenly up my sleeve. At first I could only feel rock, but then something softer met my fingers. I caught hold of it and drew a splintered piece of a wooden beam towards us.

"It must really lead into the open," said Zaunik. "We won't disturb these prehistoric remains. We'll come back another time with an archaeologist. Incidentally, it's already three o'clock in the morning. I'll go outside and shout. Perhaps we can determine where the opening is."

I remained alone. Slowly the noise of rustling and sliding grew fainter. The sound of falling stones and the brushing of clothes against rock died away. I could now only hear the noise of the wind. Since it was unpleasantly cold, I resumed my break-through work until I sank exhausted on the rock and closed my eyes for a few moments. I had to reconcile myself to a lengthy wait, for the path was long and the search outside in the open would take a considerable time. Not until an hour later did I begin to listen, but I could hear no sound of a human voice above the rushing of the wind. I began to doze again, then suddenly I woke with a start for I could clearly hear someone calling, "Hallo! Hallo!" In a flash I was wide awake. I flung myself forward into the hole and shouted back: "I'm here! What's happened?" I could only hear a voice muffled

### *Green Limestone Caves*

by the wind: "I'm in the pothole chamber of the Brunnstein Cave."

In the pothole chamber of the Brunnstein cave! So we had stumbled on a discovery which had escaped everyone else who had tried—the legendary communication between the Schöenstein and Brunnstein Caves!

We had achieved enough for one day. I started on my return journey. Zaunik was waiting for me at the cave entrance in the stormy October night.

## Chapter Nine

### CAVES AND THE SPECIALISTS

IT IS NOT only the eternal darkness of caves, the unique impact of flowstone and rock fall, which captivate the explorer and refuse to let him go, but the breath of the past which blows through the subterranean caverns. The very thought is disturbing that here neither living forces nor atmospherics can alter the scene; that the chamber in which you stand may have looked exactly the same 10,000 years ago, and that your tracks, if no one disturbs this solitude after you, will remain unchanged in the clay in ten thousand years' time. But it is unnecessary to set out on complicated trains of thought; even when results are disappointing, *the impression still remains—the impression of archaic primitive power.*

It was a long time before people realized that caves did not conceal precious metals or treasures, but something far more important—the key to the past. The archacologists were the first to realize this, followed by the paleobiologists and finally the geologists. But caves have not yet become what they could be: the arena for paleogeographers and paleometeorologists. The most significant data await them. Upon the weathering conditions, the temperature and rainfall, depend the aspects *of animal and plant life, which in turn determine the possibilities for life and the style of life of Man.* Even though this method of coming to conclusions about our prehistoric past is little practised, I wish at least to demonstrate what the spelcologist can bring to this pursuit of knowledge about this period.

The question first arises, whether observations in caves are capable of providing data which are of more than local importance. Difficult as this question is, it can be answered categorically.

Various phenomena—whether purely a question of tectonics

## *Caves and the Specialists*

(the phenomena of earth movements creating a framework of joints within which caves develop), or of water conditions which determine whether the rifts and fissures become extensive systems of passages, winding canyons or spacious chambers, or of, perhaps, the amount of carbonic acid or carbonate dissolved in the water, upon which depends whether the limestone is corroded or whether the caverns will be filled or blocked with flowstone—are all definitely related to climatic conditions prevailing at the surface, and affecting a landscape which has long since changed or vanished. Now, in many instances we know the connection between cause and effect. We can attribute oolite deposits to powerful water transport, and broken fragments of rock to weathering by frost, and traces of corrosion to the levels of ground water, but—and this is indispensable if we wish to know the historical sequence of events—we must incorporate these events in a chronological scheme. It merely needs some detective work to discover signs which will give us information.

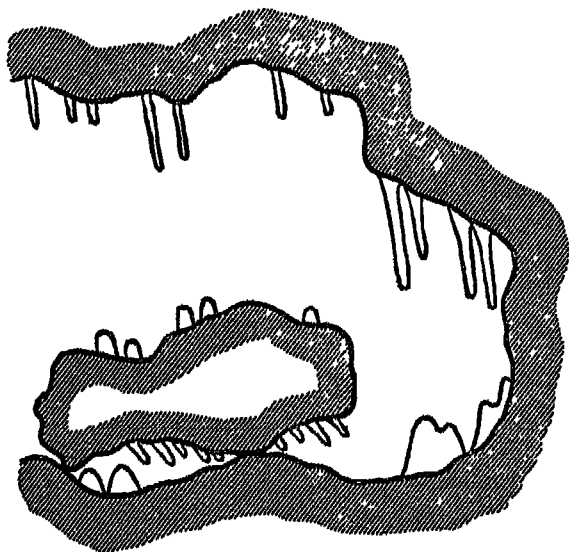
Flowstone and dripstone formations are for the speleologist what finger-prints are for the criminologist. The time will come when we shall be able to read as much from the stratification of flowstone as from a full-sized portrait of a criminal, the premise being in both instances that certain indications are available, and that unfortunately is not always the case.

Let me give you a few examples of deduction from calcite. Let us observe a cave which is rich in this mineral. Dripstone forms on the roofs and walls. In the course of time a collapse takes place, particles of the roof break off and some sections of the cave will be sealed. The corrosion continues and very soon the freshly made fractures are covered with calcite concretions.

The picture which faces the resourceful speleologist is as follows: he sees material which has fallen from the roof and finds among it broken off remains of an old dripstone epoch. He can best recognize them by the fact that the bosses no longer stand in a vertical position—he notices, too, the new overlay above the fractures, and the recently formed vertical stalactites and stalagmites. He knows therefore that the time of the collapse can be dated between the formation time of the old and the new calcite deposits.

### *Wilderness Under the Earth*

A particularly good example of this is to be found in the so-called Eisriesenwelt ("The World of the Ice Giants"). There, in the "Diamond Kingdom", is a chamber on the walls of which have been found countless calcite ledges created from a tangle of interwoven needle crystals, a proof of earlier flooding. At the spot where the wall surfaces became a network, later to be covered with water, the dissolved parts disengaged. The blocks here should stand parallel to each other and run horizontally, but they do not do this, they lean towards each other and lie at an angle and show a marked deviation from the horizontal. It therefore follows that the whole rock mass in which this "Diamond Kingdom" lay tilted during the period of formation of those particular calcite blocks.



By far the most common case is that of flowstone layers. Time and time again, between them are found clay or sandy deposits in which objects are often discovered which can be approximately dated—bones, sherds, snail shells, etc. When these beds lie loosely superimposed, the date of their deposit can only be given with the greatest care, for the geologist has to reckon with shifting deposits which could have changed

## *Caves and the Specialists*

positions from above to below. In solid flowstone deposits this possibility can be discounted.

Considerable progress would have been made to-day if we knew more about the origin of formations. Their wealth of forms obviously reflect their origin. The temperature, the carbon dioxide content of the surroundings, the wind conditions and many other factors must account for their slow or rapid growth, their rounded or pointed forms, whether they spread out broadly or remain slender, take the form of fine crystals or loose friable overlay, but we do not yet know what really caused these conditions. We occasionally hear of methods to determine the age, the temperature or the building period, but they result in complicated tables subject to great margins of error. We cannot, however, expect one branch of science which is still in its infancy to produce ideal data. Each result must be worked out conscientiously and we must be content that caves have been recognized as an aid to help us discover something about our geological past, and that specialists are at work on them. In this way success cannot be long delayed.

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The complete scientific exploration of a cave is a combined operation, in which specialists of every possible branch take part. An accurate plan is the basis for all further work, for each observation, irrespective of its nature, is correlative and must be marked on the map. To perfect this preparatory work we possess a means which is ideally suited to determine the character of the cave and to make the information available to those scientists who did not take part—the camera.

To wander around with a sensitive instrument like a camera in the wet and the dark, in constant fear of stumbling with this valuable object and damaging it, is a very dubious and nerve-racking job.

Each time I crawl out of a cave with my camera and notice that there is clay on the lens, water dripping out of the case, and that the number of scratches has increased, I resolve never to go photographing in caves again. But eventually I repack my haversack and stow next to my carbide reserves, matches, compass, and pitons, a camera, flash-light equipment and

### *Wilderness Under the Earth*

tripod, and climb down into the dank night of the underground world, wade through pools, slither over chasms and wind my way through narrow, rubble-filled tunnels with the pack tied to my feet and pushing the lamp ahead of me.

And finally I see a subject. I set up my tripod on a boulder, wind up my film, lie down and try to compose the best picture through the viewfinder—this is rarely successful—use my flash and risk taking the shot. When the roll is finished and the tour is over and I finally hold the film up to the light for the first time, I find that out of twenty pictures hardly one is a success; nineteen are under-exposed, scratched by sand entering the camera case or not sharp enough; mud or water has stuck on the lens or the objective is out of focus or spoiled by streaks of light. My assistant may have passed while the shutter was open without shielding his lamp, or a rain of sparks may have fallen from the flash-powder across the field of vision, or the lighting was wrong, or the camera had merely failed to take the intended scene. No one will be surprised, therefore, that I only once went photographing in an unexplored cave.

How often did I have to take my shots in impossible positions: lying on my belly in the water, as in the Köhlerwandhöhle near Lehenrotte, standing in the mud, trying to take a close-up of a cave louse and tumbling with tripod and camera into the muck; or in the Kleinhäuselhöhle in Jugoslavia at the edge of an abyss near a waterfall, where the spray wet my flash-powder eight times before it fired; or in the Bärenhöhle by the Torren Waterfall on the borders of Salzburg and the Berchtesgaden area; or in a chimney holding the camera between my legs, as in the Eastern Almborg ice cave on the expedition to that cavern!

Towards the end of the great expedition to the Ötscher ice cave in 1953, I once climbed alone out of the innermost section towards the exit. The imposing picture of a giant tunnel-shaped, slightly rising gallery, romantically lit by the entering sunbeams, intrigued me so much that I decided to take a picture with natural lighting. I set up my camera, carefully worked out the time exposure and ran as fast as I could over loose scree in order to be in the picture—I had to hurry unless I wanted to appear in the photo as a transparent ghost—and sat down on a platform of rock to bring a human interest to the

### *Caves and the Specialists*

composition. Hardly had I sat down than I noticed that I had chosen a spot where the melting snow trickled down from above. I could not move and I was obliged to sit there motionless in the dripping wet for a quarter of an hour, since the daylight which penetrated the cave was weak. Nevertheless, I lasted it out and got soaked. My teeth were chattering. I ran back to the camera and closed the shutter. When the film was developed I found that I had sat too low down and did not appear in the picture at all.

I was in for a particular surprise when photographing in the Hermann's Cave in Lower Austria. With a few friends I ventured into the rarely visited deepest regions, which could only be negotiated by a lot of difficult climbing. We descended into the deepest chamber and from there made a further climb to explore certain side galleries. The second deepest storey, the so-called "Fan Palm Hall", offered the most wonderful material for photography; some of the dripstones hung in branches from the roof to the floor. I hurriedly made my preparations and measured out a very large dose of flash-powder. Hardly had it ignited than I thought by the wave of some magician's wand I had been transported into a witches' cauldron. The chambers began to wobble and weave; white mist appeared from nowhere and disintegrated before my eyes. I can only explain the phenomenon in the following way: the air was saturated with water and so the concentrated heat necessary to cause a flash was lacking. My first attempt had only produced smoke.

We could not explore the chamber any further, because we could not see our hands before our faces. It cost us a great deal of effort to feel our way over the rock walls and up the rungs of the rope ladder. I think we were all very relieved when we emerged from this steam-filled laundry.

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The problem of caves and limestone water are basically closely connected. There are few caves in the formation of which flowing or static water did not play its part, even if to-day they have long since become dry.

I have already explained how flooding water gradually bored deeper. While the upper systems in the Austrian Alpine



### *Wilderness Under the Earth*

limestone are now free of water, one finds enough deep levels at which the water still continues its work of erosion. They are usually still in communication with the upper vadose zones which to-day only become active after heavy rainfall, when the water piles up in the phreatic zone, thus locally raising the water table. Those sections which occasionally carry water usually represent the entrance to the still active parts. The best time to visit them is the winter when the downpours are in the nature of snow and there is no fear of flooding. In good weather—if one can ever talk of good weather in the mountains—an attempt can naturally be made in the summer.

A visit to a water cave shows us the world of caves from an entirely different angle. The roar of rushing water underground is deafening. Some times it covers a wide stretch of the floor or eats its way through a narrow canyon, blazing a trail, whirling and foaming, smoothing and rounding off the rocks, forming veils of sparkling drops, throwing a cloud of spray into the air. I devoted a whole summer to the water caves of Salzburg and visited the source of the Rettenbach wilderness between Ischl and Bad Aussee, the caves on the Lueg Pass, and finally the Bärenhöhle by the Torren Falls.

In the summer of 1952, Gustave Abel led our French guest, Jean Corbel, the limestone morphologist Hubert Trimmel and me up to the entrance of the Bärenhöhle. It was not long before we were stumbling across a patch of scree through a horizontal entrance into the cave, which only serves as a water vent in times of heavy rain. After an almost right-angle bend to the left, we could hear the thunderous roar of the Falls. A wide gallery near a rock fault led us straight ahead; and the water-worn surface lay like a roof above our heads at an incline of 45°.

At last we reached the torrent. It came from high up out of clefts in the roof and crashed at our feet over ten-foot deep terraces into a broad fissure.

Corbel is an exceedingly active explorer. To examine the terraces, to guess the continuation, to plunge into the water and leap down is all the same to him. For a few minutes we could still see his lamp. It flickered from a hook on his steel helmet which was joined by a tube to a strapped carbide container. Then he disappeared in the darkness.

### *Caves and the Specialists*

In the meantime we wandered about above, and Gustave Abel showed us the huge pile of fossilized bear bones for which the cave is famous. I followed the Falls a little upwards and looked around. Not a sign could be heard of Corbel.

Finally we began to wonder. Below us were steep pitches. Corbel could have fallen. Hubert belayed a ladder to a boulder and I slipped down holding on to the life-line with the water-sluiced rock close to my belly. Although I could not avoid coming into close contact with the water, I arrived below comparatively drier than Corbel. I stood in a spray-filled chamber at the back of which yawned a black chasm, the gateway to a descending branch of the cave. Overhead I could see my comrades' lamps, but communication was impossible for the noise of the torrent in this narrow passage had become a thunderous roar. I pointed to the hole and lowered myself. . . . There were terraces on the way down and I could descend without much effort, the only difficulty being to avoid the water. Sometimes it splashed over my feet. Another terrace, the roof lowered and the space between it and the surface of the water narrowed. I slipped through just above the water. If it rose only a fraction in the next few minutes, I would be caught in a trap.

The soil slipped away under my feet. It consisted here of rubble, the smallest fragments being about the size of a man's head; round or egg-shaped, smoothly polished pieces of rock 3 feet in diameter were quite common. They were unpleasantly loose and spun under foot. A little further on I came to a cone of clay. The water gurgled in a cleft in the floor and I had to make my way over wet, dark-coloured clay deposits as sticky as paste. Once more the roof lowered. It smelt stuffy down here and even the noise of the water seemed to be stifled. Where was Corbel? Had I overlooked some fork? "*Hallo, Monsieur Corbel! Où êtes vous?*" A dull rustle issued from below. I planted my feet securely, taking care not to slip, and saw below me a dark figure—Corbel. "An air current blew out my light and I hadn't any matches," he shouted up to me. "Give me a light, will you?"

That was easily done. I was delighted that nothing more serious had happened. Corbel had done the only correct thing

## *Wilderness Under the Earth*

by waiting patiently to be rescued, because to wander about caves without a light is always fatal.

The problems of limestone hydrology are not only of scientific interest; they also have a practical significance, above all, in the matter of water supply. When a decision has to be taken as to whether a limestone source is to be utilized, this should only result from an accurate knowledge of the subterranean water conditions. It is certainly far from intelligent to forbid all caving activities in the area of the Vienna Mountain Water Supply System. It is a well-known fact that limestone streams often change their course or flow underground! It may be that the water which appears to-day below as a source, already flows somewhere up above through inhabited regions as a harmless brook into which pour the waters from drains. Furthermore, the subterranean water veins are usually connected with the surface through fissures: it is vital to know the location of these shafts. Many peasants fling their dead cattle into potholes, and in uninhabited game regions animals often fall into them. Naturally, this makes the water unfit for drinking and the danger can only be avoided by conscientious exploration of the underground regions.

The mapping of these water veins is therefore one of the most rewarding tasks of the speleologist. At places where the rivulets percolate into inaccessible fissures, he must make a colour test. A harmless dye, fluorescein, is thrown in the water; observers sit by all the springs in the neighbourhood, registering the reappearance of the coloured water. Recently, the Styrian Caving Group in a similar way, by dissolving cooking salt in the Lur brook at Semriach, found out which of the springs it feeds in the Peggau coombe—a problem which had remained unsolved for many years.

Jugoslavia possesses the most magnificent water caves. Here they are not merely rivulets which flow alternately below and above ground, but fair-sized rivers. Time and time again in the classic limestone region between Trieste, Ljubljana and Fiume (Rijeka) one finds streams issuing from gigantic openings only to re-enter the caves after a few miles, and on the level plateaux it is not uncommon to meet with dolines where the

### *Caves and the Specialists*

roar of underground rivers can be heard. The Slovenian karst is a landscape with a charm of its own: most of the area is waste-land from which pale limestone crags tower; trees are rare and then only stunted ashes and hornbeams, and the only patches of luxuriant green are the *poljes*—the coombes with no outlet for the water except underground, and the dolines—the funnel-shaped depressions denoting cavern collapse.

The inhabitants of this country are as poor as the soil from which they earn a living and as tough as the willows of the high plateaux which bend but do not break before the cold north-east wind, the *bora*. Nowhere have I met people who are so naturally modest, charming and gay and more eager to explore their land—this invariably means caving.

Some of my most cherished memories are the days I spent with my Yugoslavian friends in the cave regions of Postojna and Skocjan. It was my first visit to the Slovenian karst and to the Postojna Grotto, where scientific cave exploration really began. Like thousands before me, I stood dumbfounded before this dripstone wonderland into which a small-gauge railway leads for about a mile and a half.

Our first steps brought us to a hall, the roof and walls of which were pitch black with only a very occasional patch of white.

"The war did not pass by here without leaving its mark," explained Franci Bar, my comrade from the Tauplitz expedition. "The black you can see is the trace of a fire which raged here for a whole week. The Italians used the cave as a dump for oil and petrol to protect them from bombing attack, until partisans stole up along the galleries from one cave to another and set the fuel on fire. As a result of the heat, stalactites and blocks of rock fell from the roof. You can still see the scars to-day."

We followed our guide along even paths through illuminated chambers full of columns and draperies, gours and dripstone bosses of a size I should never have dreamt. Their splendour increased at every step. Stalagmites towered 30 feet towards roofs covered with an amazing tangle of glittering stalactites until we finally reached "The Concert Hall", a gigantic chamber which could hold more than 10,000 people.

## *Wilderness Under the Earth*

And then we climbed "The High Mountain". In an impressive hall, this 150-foot boulder pile rose into the air to within 55 feet from the vaulted roof. The path wound its way through a primeval forest of stalagmites, between calcite-coated boulders tree-high pillars and a jumbled mass of fallen stalactites.

This easy path continued between bizarre and glittering formations until finally we entered a man-made tunnel beyond which visitors do not normally go. It was the path taken by the partisans when they set fire to the petrol dump in "The Black Grotto" (Črna jama). Once more ahead of us lay a high chamber full of stalactites, then we wended our way through damp, narrow corridors which had been blasted out of the rock. But we did not have much time to remain in these bleak galleries. There was a dull roar, a hole gaped to the left, giving us a glimpse of a pitch black abyss, the underground river bed of the Pivka which we now followed until a faint light appeared ahead of us. We had reached the Pivka jama, the Pivka cave, which would lead us back to daylight.

For a further 10 furlongs the stream remains unexplored; then it reappears in known regions, in the Malograjska jama ("The Little House Cave") from which it emerges as the Unica in the Planina Valley.

The Yugoslavian cavers continue to explore this water tunnel ever deeper and further. In the gigantic clefts of the križna jama, in the vaulting of the Malograjska jama and in the Škocjanska jama, near Loz, they climb up the walls or use rubber dinghies, but the connections between the Rijeka, the Pivka and the Malenska, as they are all called, still remain a mystery. It is an inexhaustible region. For centuries it has been known as one of the richest cave regions, but it still preserves secrets enough to astound generations of speleologists.

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Whenever there is mention of the fantastic power of water, of its dissolving and excavating powers, of its ruthlessness and monstrosity, I always think of the Hölloch in Switzerland. This name makes the heart of every caver beat faster. Two facts have made it famous: firstly, it is one of the largest caves in the world, a seemingly endless labyrinth of galleries and tight

### *Caves and the Specialists*

crawls, of which to-day about thirty-four miles have been explored; two American caves, only, exceed it in length—the Carlsbad Cavern in New Mexico with thirty-eight miles explored, and the Mammoth Hole in Kentucky the extent of which, according to the latest reports, is estimated at over 150 miles. Its second claim to notoriety was the stranding in the summer of 1952 of four cavers who had to wait inside the cave for 224 hours until the water ebbed and allowed them to return to the light of day. Professor Alfred Bögli's adventure gave the Hölloch the reputation of being an exceedingly dangerous and treacherous cave.

The first parts of the system covering about 3 miles were already well-known, but in 1949 a large-scale exploration was organized. Two groups set out independently, to explore the extension: the S.S.S. (*Société Suisse de Spéléologie*) team, led by A. Grobet, and the S.A.C. (*Schweizer Alpenclub*) led by H. Nünlist. To the explorers' surprise, they had found a host of promising entrances which encouraged them to begin a systematic examination of the cave. For this reason, the S.A.C. Hölloch Exploration Union was founded, its technical adviser being H. Nünlist. Professor Bögli undertook the scientific leadership, and seldom has a man embarked upon a task with such enthusiasm as he did on his work in the Hölloch.

Year after year I heard of newly discovered stretches, but I never met anyone who could give me first-hand information until I found a letter on my desk from Professor Bögli inviting me to visit this cave.

It was a bright December morning. I sat in the car next to the Professor and had an opportunity of watching him in profile; resolute eyes beneath a broad forehead, a powerful nose above slightly curling lips, a man who carried out what he had undertaken but who obviously possessed a healthy and good natured sense of humour. All this I learnt from his cheerful words as he explained the neighbourhood to me. We were driving through historic country. Schwyz, the scene of William Tell's struggle for freedom, was left behind with its old artisans' houses; a broad valley opened out and then gradually narrowed into a gorge before we pulled up outside a group of houses from which emerged a few grey and yellow clay-stained figures

## *Wilderness Under the Earth*

with acetylene lamps and rucksacks. It was a familiar, almost homely picture, and I hurried to get into my own caving clothes.

This did not take long and in the meantime darkness had fallen. A necklace of lights wound its way up the powdered snow to the mountain. Professor Bögli was going to show the cave to a group of young members of the S.A.C. and we had to use the hours of darkness if we wanted to reach the inner system.

Soon we left the broad path and took a side track near a deep canyon. Now we were in the cave region. The canyon was an earlier cave entrance, the roof of which had fallen in.

We entered the gates of the underworld beneath a natural bridge. The cave begins with a built-up part; for 650 yards the visitor can walk with the guide past eddy sumps and turbulent streams into the mountain. The paved path finishes at "The Chancel" and from thereon the scene changed to extensive sand halls leading into the depths.

I was the first to join Professor Bögli below on a pile of scree and sand, and then one dark figure after another appeared beside us, leaving a wake of sand as it slid down the slope.

"We are now in one of the deepest parts of the cave," said the Professor. "In the rainy season the water rises from below, spurts out of every crack and fills this chamber to the roof. Then the gallery which we have just taken becomes an underground stream. The water sometimes rises another 300 feet until it reaches the level of the entrance, pours out as a spring and thunders down into the canyon below."

"Are we in danger of being trapped?" came a voice from the background.

"This danger is always present," replied the Professor, "but it is slight in the winter since the rainfall turns to snow and lies on the surface. Well, come along!"

Now we began to scramble up the channel which the water had excavated, and I—going through the familiar routine of cave climbing: find a foothold, feel for a grip for both hands, haul up the body, crawl over the jagged floor of galleries, negotiate ledges on all-fours—had plenty of time to look at my surroundings. The shapes which the water had cut out

### *Caves and the Specialists*

of the walls were wonderful: scallops and grooves, ripple marks, Nature's portrayal of the direction of flow. I was also struck by the way this part of the cave looked clean and polished—not a speck of dust was to be seen in the rills, not a pebble crackled under foot and the damp walls looked as if they had just been left by an army of charwomen who had polished them to perfection.

The path was long. Although I have a good caving memory, I can only remember a few characteristic spots: the so-called "Evil Wall", 130 feet high which is quickly climbed with the help of a 100-rung ladder; a barrage of stout wooden beams with which it was once hoped to halt the meltwaters, before they were smashed like matches under the force of the dammed water; an overhang down which the "Little Höllbach" trickles, conquered by means of a ladder; and a series of lakes filling the entire gallery, which we negotiated by hugging the wall and using the rocky projections as stepping-stones.

The stretch gradually lost its freshly-washed appearance; sand and clay lay among the scree and stuck to the wall. We had left the flowing water and reached the ponding-up region.

We were approaching "The Giant Hall"—the entrance was now 2,200 yards away—and here we took a very short rest, although we had far too little time at our disposal and could only cover a very small part of the system. As in a dream, the marvels of this underworld slipped by: "The Hall of Rain" in which a waterfall has eroded a deep, narrow canyon; "The Witches' Cauldron", then by an 80-foot vertical pitch to "The Chasm of Death", circumnavigated on a small sloping ledge; "The Heavenly Way", the floor and walls of which were covered with gypsum crystals—Professor Bögli found one the size of a walnut and as transparent as glass—the orange-red translucent stalactites of the "Salle Anglaise" and finally, on the return journey, "The Water Cathedral" in which, near a natural bridge, a waterfall thunders down into a small lake gleaming below. My companions hustled to and fro and I stood somewhat in the background watching the flicker of the lamps on the bridge of rock and their reflection in the water below. The cool damp air swirled around us and I could feel the spray on my face and hands.



## *Wilderness Under the Earth*

In silence we crossed a series of now dried-out water conduits. It was not our weariness alone which made us fall silent but far more the deep awe that this mighty chamber aroused. We ate our last provisions in "The Giant Hall", the starting point for our return journey.

Here, Professor Bögli, removed a cave log-book from its tin container and jotted down a few notes, but it was not the one which the four men who got cut off in 1952 used for their observations, for that lies in the archives of the S.A.C. Hölloch Exploration Union.

"We had extraordinarily bad luck," said Professor Bögli, telling us about that occasion, "because during our surveying work there was a cloud burst. When we came near the sump we found our way barred by a lake, and noticed that the water was rising higher and higher. We retreated into 'The Giant Hall'. . . ."

I could easily imagine the feelings of the trapped men. Even now, in the dry season, water trickled out of every nook and cleft with a gurgle and a splash. What could be more terrifying than when this light, vague rustle suddenly swelled to a thunderous roar; rivulets appeared underfoot and the water began to fill the cavern!

The four explorers had intended to remain only one day in the cave, so they had taken a very small quantity of provisions and neither blankets nor sleeping-bags. They waited for nine days at 6° C. in the damp air and the numbing cold.

Professor Bögli continued his account on our way back to the main entrance. He showed us the spots where he could observe the rise and fall of the water-level and pointed to the clay coating on the roofs and walls of the galleries.

"Here you can still see the traces of the last flooding," he added, scraping off some friable clay with his finger-nail. A light, cold air current blew through the chamber.

"As long as the wind is blowing, the siphons are open," he explained. "For the first time, when, after nine days of enforced waiting, we heard the rushing of the wind we knew that our hour of delivery was at hand. And yet the break out was difficult enough." He pointed to a fault 10 feet above the gallery floor. "Along this cleft, which at that time lay just below the

### *Caves and the Specialists*

water-level, I felt my way through the lake up to my shoulders in water. My comrades held me on the rope and then I in turn helped them to cross this dangerous spot."

This must have been a truly astonishing performance after ten days of hunger, cold and privation.

It is ironical that in spite of the rescue action which was staged at the time to free the trapped men no one was waiting for the four men beyond the siphon. When they emerged they even found the iron gate closed and had to break it down to make their escape.

\* \* \* \* \*

In the inconceivably long interval of time between the birth of our earth from glowing magma and the present, the age during which man appears on the scene occupies only a momentary period of time. The first traces date from the Diluvium (see the Table on page 86). Interglacial periods created climatic conditions which were favourable to the development of primitive cultures.

Our forefathers were nomads who depended upon hunting. Since they did not yet understand how to build houses to protect themselves from the cold, or against animal or human enemies, they had to rely on natural habitations, above all on caves. In these have come to light bones of slaughtered beasts, of bison, mammoth, reindeer, wild horses, and artifacts such as axes, scrapers and stone knives.

The most important remains of the earliest prehistoric race were the skeleton found in a cave at Neandertal near Düsseldorf. The man of this age was christened *Homo neandertalensis*, in other words, Neandertal Man. The bones were so firmly embedded in floorstone that most of them were beyond recognition, and only a skull, a few toes, a broken pelvis, the right shoulder-blade and five ribs were recovered; everything else was lost.

Our knowledge of the customs and development of these hunting people are mostly due to the speleologists. For months and years on end, they returned to their dark kingdom and with tiny shovels carefully scaled off layer after layer, packing them all in a sack, and then above ground subjecting them to a

## *Wilderness Under the Earth*

long wearisome scrutiny, classifying the few finds that referred to humans—scientific treasure trove in the truest sense of the word.

This work only leads to success when it is carried out with the most painful accuracy; the thick clay or calcite crust usually crumbles to pieces and the valuable find is lost in the hands of the amateur. Very often it is completely overlooked, for the older it is, the less it has been fashioned. The tools of the oldest cultures are no more than pieces of flint pointed by striking them or sharpened against a rock. To differentiate systematically between fashioned and casual flints needs years of long experience. Not until the skill of man developed down the centuries could tools and weapons be differentiated and now be easily identified. Unfortunately, inexperienced excavators often cause great damage; they recognize only the more significant, more recent remains and throw away valuable discoveries.

Casual excavation by laymen entails a second danger. For the archaeologist it is not only the appearance of the find that is of interest: of far greater importance to him are the site, the position of the object in the soil, the type of workmanship, the depth of the strata below the surface, and finally the wealth in finds of the neighbouring beds, etc. Someone who by chance finds a fashioned flint or bone and in his first enthusiasm removes it from the spot where it has remained undisturbed for centuries to show it to an archaeologist must not be surprised if the latter displays very little enthusiasm. For now, perhaps, there is no way of telling to which culture the find belongs; any further conclusions to be drawn are invariably bound up with the presence or lack of neighbouring beds, the human settlements in the region, the flora and fauna and also the climatic conditions of the age in which it originated.

This is why the archaeologist pays particular attention to the layering and has to recognize what belongs to this or that strata, where one of them ceases and the other begins, whether the deposit has been disturbed or whether an upheaval has taken place. He starts by laying bare the upper and most recent bed, looks for culture remains and passes on to the next, often coming across barren layers followed by others rich in treasure.

### *Caves and the Specialists*

Sometimes he has to cut through limestone roofs beneath which the valuable older objects lie.

It is to be understood that the zeal with which the professional carries out this research is often looked upon with distrust by ordinary folk. They cannot believe that he is merely in search of sherds and fragments of charcoal; they suspect that he is looking for hidden wealth. But when nothing else is brought to light from the clay and marl strata their mood often changes to compassion and mockery. An archaeologist, after his excavations, once received from the nearby villagers a case full of broken china plates, old coffee cups and soup bowls.

Another well-known speleologist called Erler was at one time the victim of a similar practical joke. He was digging in a cave in which he found nothing except an almost undamaged, mud-coated clay vessel. In great excitement he carried his find home and cleaned it very carefully with a fine brush. At last some letters which had been scratched on it appeared and his surprise can be imagined when he deciphered it as:

To My Dear Erler  
From Caius Julius Caesar

The brief table on page 152 compiled by Professor Lothar F. Zotz, one of the best known authorities on the Paleolithic Age, and at the same time one of the leading experts on beds and deposits, gives us a rough picture of the prehistoric stages of culture and their characteristic finds.

\* \* \* \* \*

Among the most imposing finds must be numbered the cave paintings in the Franco-Spanish frontier region, artistic masterpieces of great perfection and maturity—paintings, engravings and drawings on cave roofs and walls, coloured hunting scenes and sketches of beasts and men. Clay sculpture has also been found.

The most important centre for these cave pictures is the province of Santander in northern Spain. This is the site of the famous Altamira cave in which the first of these Stone Age works of art were discovered. Argument as to their genuineness lasted for more than twenty years.

## *Wilderness Under the Earth*

YEARS BEFORE THE PRESENT DAY	AGE	CHARACTERISTIC FINDS
2000—1500 2500—2000 3000—2500	Folk migrations and the Roman Empire Late Ice Age Early Ice Age	Iron weapons and utensils. Bronze, silver and gold jewellery. The first hand- turned pottery.
4000—3000	Bronze Age	Utensils, weapons, jewel- lery of bronze. Gold jew- ellery in the North.
6000—4000	Neolithic Age	First metal ware (copper). Pottery of many shapes, designs and styles. Pol- ished and bored utensils and weapons of flint.
12,000—6000	Mesolithic Age	Beaten and polished flint tools, among them the most ancient axes. Hollow cudgels. The first primi- tive pottery.
More than 1,000,000—10,000	Paleolithic Age	In the later period, sundry artifacts of flint, bone, ivory or other plas- tics. In the older period, fashioned flint axes.

Not far from Santillana del Mar, in flat country, a hound one day fell into a rock fissure. His owner, on sweeping away fragments of rock and rubble from the hole in order to free his dog, noticed that the opening was the entrance to a roomy cave.

Ten years later, in 1879, the archaeologist Don Marcelino de Sautuola remembered the cave and often strolled across the meadows and fields from his nearby castle to the doline to dig for treasures in the depths. He returned night after night with a splendid booty.

It is now a well-known story how one day he took his five-year-old daughter with him on an excavating expedition. While he was intently examining the strata for human remains from the Ice Age, the child stared in curiosity at her unusual surroundings. Her eyes fell upon the roof and there were pictures—living pictures, bright coloured pictures of cattle, horses and bears.

### *Caves and the Specialists*

At first her father laughed at her childish imagination, but soon he saw how wrong he was. He immediately understood the full implications of the discovery and hurried through the cave lighting up the roof and walls; on all sides he discovered marvellous new pictures—a bison painted in warm russet-brown hues, bordered with black; an ibex caught in its flight by the use of the natural bulges of the rock face; a mammoth drawn in thick, greasy colours and countless scratched sketches, catching the essential features in strong, powerful lines.

Portraits of long-extinct beasts in this abandoned, subterranean corner of the earth! There was no doubt in de Sautuola's mind that these were works dating from prehistoric times, remarkable proof of an urge to draw and a power of expression which no one had previously attributed to our Stone Age ancestors.

It is not surprising that scholars doubted the authenticity of these pictures. Their very existence contradicted so many of their previous theories. They suspected a forgery and suggested that de Sautuola had engaged a famous painter with a view to causing a sensation.

To-day the genuineness of this cave art is beyond doubt. In many caves pictures were found on the walls, overlaid by undisturbed stratas; others were coated with a thick layer of calcite which had to be chiselled away before they could be seen. In the old culture strata, bones and stone discs were found with hasty sketches which had obviously served as rough drafts for a great wall painting.

We now have no difficulty in imagining the past from these hieroglyphics—details of a long-vanished animal world, the way of life of those men, their culture and religion. It is believed that the paintings had a mythical significance and were designed to bring luck on hunting expeditions and to pacify the spirits.

The most recent great discovery in the field of painted caves was at Lascaux, near Montignac in the Dordogne. Here, too, a dog was instrumental in finding it. Five boys were rabbit-shooting on a hill near the village when one of them noticed that the dog had disappeared. After a search, they found him in a pothole and when the opening was broadened the eldest of the boys forced his way in. He slipped about thirty feet into

### *Wilderness Under the Earth*

the depths, fortunately without doing himself any harm, and the other lads followed. They struck matches, picked up their little dog and then noticed all around them on the walls of the cave the remarkable series of drawings and engravings of the main hall. They were the first to see these examples of prehistoric art for 15,000 years.

For a few days the boys kept their discovery to themselves, then their schoolmaster was told, and he called in Abbé Breuil, the great authority on this period of art. Soon scholars, artists and inquisitive laymen followed, and to-day a wide motor road leads to the cave which thousands of visitors see every year. The small village is now a place of pilgrimage.

Not far from Lascaux is Les Eyzies, nestling on the edge of an overhanging rock face. This delightful village lies in what was once a great prehistoric centre; nearly all the niches in the neighbouring limestone walls were inhabited in the far distant past. Here is also located the cavern of Cro-Magnon, in which the bones of men, living more than 80,000 years ago, were found. To-day no memorial remains of this famous discovery, except the garage of the Hôtel Cro-Magnon which occupies the site!

On the other hand, not far away, lie half a dozen of the most famous painted caves. Font de Gaume contains magnificent paintings, although they lack the freshness of those in Lascaux, and a few engravings.

In the craggy niche of Cap Blanc, Stone Age artists chiselled relief portraits of a bison, a reindeer or an ox, and several horses exploiting the natural contours of the rock. In the La Mouthe cave, the engraved drawings had to be laid bare from undisturbed beds—an irrefutable proof of the genuineness of the work. The 280-yard-long entrance to Les Combarelles possesses the richest selection of different animal pictures. It requires a certain amount of patience to distinguish the engravings from the natural unevenness of the rock surface. But suddenly the forms reveal themselves as mammoths, wild horses, bison, reindeer, wolves, lions, etc. At the far end of the gallery is the solitary picture of a man: a dancing sorcerer.

About forty-seven miles away, not far from Cabrerets, is the Pech Merle cave, which contains magnificent dripstone

## *Caves and the Specialists*

formations, but it was necessary to cut through the calcite before reaching the interior. In a cave about 320 yards long the walls are decorated with some forty pictures of mammoths, cattle and horses in great confusion. Here and there can be seen imprints of hands. What they signify can never be proved, but it is easy to guess how they came about: the artist laid a hand on a part of the wall which had previously been prepared with grease, and blew on coloured powder thus silhouetting the palms and fingers. Not far away is a second rarity: in a calcite basin footprints, traces of a long since extinct race of men, can be seen petrified in the limestone as clearly as if they had stood there yesterday.

About one hundred and fifty caves are known in which traces of Ice Age art have been found; the most recent discoveries are in southern Italy. It has been pointed out that all these finds are distributed within certain latitudes and this gives rise to the question: Why are there no similar pictures in Central Europe?

Many speleologists attribute this to the fact that in this region the roofs and walls of the caves were subject to much greater differences in temperature and so to greater change, with the result that all the pictures and engravings must have been destroyed. Others, however, are of the opinion that here and there in remote places similar cave paintings and engravings must exist and they are constantly in search for them.

Not all caving finds were due to accident. I should like to quote as an example the discovery of the Montespan Grotto to show the working methods of a man who has incidentally become one of the most famous and successful speleologists in the world—the Frenchman, Norbert Casteret.

His happy hunting-ground has always been the Pyrenees. There he discovered the original source of the Garonne and the deepest pothole in the world, the Casteret Ice Cave, and in 1953 he was in the pothole of Pierre Saint Martin, the scene of the Loubens tragedy.

The Montespan Grotto is also on the border of the Pyrenees. It had long been known to the local inhabitants that the waterfall, which comes into the open through the cave entrance, could be followed for some 65 yards, but at this point was one



## *Wilderness Under the Earth*

of the notorious sumps, where the cave roof sinks below the water-level.

Casteret learned of this as a young man when he stood before the entrance in 1922, but siphons had long since lost part of their terror for him. In a bathing costume and armed with a lamp, he made an entrance and was soon squatting in front of the temporary end—the sump.

Casteret never takes long to make up his mind. He was intrigued by the dark, slow-moving water and the secret that might lay behind it. He let fall a few drops of wax on a convenient spur, stuck his candle on them, and then, taking a deep breath, he slipped into the icy water. Feeling his way along the roof with his hands he swam into the unknown. After a short interval of intense effort he felt the roof rising and surfaced to recover his breath. Impenetrable darkness enveloped him. Without hesitation he turned round and swam back the way he had come, for he had to avoid losing his sense of direction in the dark. He reached his point of departure safe and sound.

On the following day he was better equipped when he dived into the sump. He carried candles and matches in a waterproof cap and would thus have light beyond the dangerous point. For a few minutes he waded under the deep roof until he came to a second sump. Although a dry gallery branched off here, Casteret forced this obstacle by diving, because he wanted to explore the watercourse. Beneath a low-hanging stalactite-covered roof he advanced along the bed of the stream, using his hands and feet, and keeping his head above water in the little air space. He reached a larger chamber and a further narrow passage until finally he came to floating brushwood; this told him that he was not far from the end of the underground stream, and on the following day his suspicions proved correct.

He spent several days in succession in the cave and discovered new water-free galleries until eventually a period of rain interrupted his work. The summer of 1923 was unusually dry and Casteret and a comrade were able to force the first sump without diving. For the first time he entered the dry gallery which he had spotted on his first visit, shortly before reaching the second sump. He wandered along it for 200 yards; it suddenly narrowed

### *Caves and the Specialists*

and the roof lowered. Then something caught Casteret's eye in one of the flooded clay beds. He splashed through the wet mud towards the object and found a flint axe.

Now he was highly excited. He hunted for a second object and suddenly recognized the form of a cave bear sculptured in a lump of clay—the sign of a highly developed art. A start had now been made. He came upon one find after another: engravings of ibex, chamois, hyenas, mammoth, wild horse and bison, clay figures, sculptured clay mounds, clusters of stalactites, engraving tools and also the footprints of men and bears.

As soon as Casteret's discovery became known, a group of volunteers joined in the work of deepening the stream bed to allow the inexperienced to enter. After a few days this excavating task was finished and the way to new knowledge stood open.

Casteret may be called rash and obstinate but no one can deny him recognition for his achievement.

\* \* \* \* \*

Darkness, the cold, and the dampness of caves are in general not particularly friendly to life. In places where the light and the warmth of the outside world still penetrate, in the entrance region out of the wind and rain, many animals and plants naturally settle—butterflies, mosquitoes, owls, ferns, mosses, green and blue algae. But further inside, in the perpetual night, it is rare to find anything living; those few exceptions are therefore all the more interesting because their organism has evolved to suit the particular requirements of the cave. Thus, for example, the eyes are often veiled, while the hearing organs and antennae are particularly well developed. Blind cave beetles with long, spidery legs and feelers, whose nearest relations are to be found in the Mediterranean and in the open air, are known in the Alps. It is probable that in the Diluvium before a glaciation, some species took to the caves and, in the course of time, adapted themselves to the conditions there, while those who remained on the surface became extinct.

The strange characteristics of the cave proteus are well known; it only opens its eyes when brought into the light and is oviparous or viviparous according to the temperature.

## *Wilderness Under the Earth*

The bat has posed many problems. It is only a cave-dweller during the long winter months, when it retires into caverns to hibernate. It was a mystery how these beasts could fly in perfect safety in the darkness without ever crashing against the rock walls. Only in very recent times has the answer been discovered; they are equipped with organs with which they transmit and receive sound waves, similar in principle to radar, one of man's latest scientific achievements.

The main interest of the modern biologist is in the past. The floors of caves, in addition to traces of vanished cultures, hold the key to the flora and fauna of prehistoric times. These are titbits for the paleobiologists, the scholars who have classified fossil plants and animals as a result of their researches. Here, too, the same detailed work is necessary as in examining culture strata, the same raising and sorting of bed after bed. Bones, teeth, and horny substances, such as antlers, are the only parts of the beasts which have so far been recovered, and from them the scientist reconstructs the building of the muscles, its aspect and mode of life. Although, for example, no one has ever seen a cave bear, there are few natural history books in which an illustration of him, reconstructed by the paleozoologist, will not be found.

The paleontologist and paleobiologist have the same working field—the bed deposits on the cave floor. Yet there is no rivalry; on the contrary, their work is complementary. Not every strata can bring a find to the archaeologist, and in this event he has no method of dating it. At this juncture the paleontologist steps in. From the fauna he can decide whether it is a question of a cold or a warm period, a glacial or interglacial age. And the same conditions are reflected in the deposited beds.

The Nuremberg paleontologist Georg Brunner, as a result of conscientious work, has compiled tables of the glacial and interglacial periods which far exceed in detail any other attempts in this field.

Naturally, the paleontologist can often give a helping hand, for in this communal work there are invariably gaps. Sometimes small mammal bones are lacking and at others undescribed objects are found; in each case mutual aid is necessary.

### *Caves and the Specialists*

And this is not all. Now comes the geologist to find inclusions in the strata which puzzle him or tell him something about the ancient conditions of waterflow, sedimentation, flooding, weathering and climate. And once more a few details are added to our picture of the past. Each of these sciences plays its part. The geologist, the morphologist, the paleometeorologist—each adds a stone to the edifice of our combined knowledge of the past, the living and the dead content of the cave. Each must respect the knowledge of the other, each must be modest and confine himself to the field in which he is a specialist. That our understanding of the cosmos is not split up into separate isolated faculties but is uniform and integrated can be realized no more clearly than by the spelcologist, be he geologist, biologist or archaeologist, all of whom work with their comrades to wrest one more secret from the damp, cold vitals of the earth.

## *Chapter Ten*

### ICE CAVES

SNOW CAPS AND perpetual snow, I think everyone will agree, are the greatest charm of mountain peaks. Their subterranean equivalents are the glaciers of the ice cave systems, the most famous of which are to be found in the Central European Alps, in particular the world-famous Dachstein Caves and the Eisriesenwelt.

The Dachstein limestone mass is one of the classic cave regions. In the Salzkammergut, above Obertraun, at the eastern end of the Hallstättersee, a gully splits the north walls of the Dachstein in two. After about a mile this becomes the Schönberg Alp, a shallow depression with sides rising almost vertically. Only to the north is there an uninterrupted view—surrounded by mountains, Lake Hallstatt looks from above like a gigantic eye. Everywhere in the walls yawn the dark entrances of countless caves, including the Mörk and the Kraul caves, the Holzknechtloch and the Backofen, but above all the Dachstein Ice Cave, the jewel of the Salzkammergut, and the Dachstein Mammoth Cave which, with its 17 miles of galleries, is the third largest cave in Europe.

The first definite report of the Dachstein Ice Cave dates from the year 1910. When one of the local inhabitants was caught in a thunderstorm, he took refuge in a cave entrance which had long been known to the shepherds. On hearing this man's tales, Georg Lahner of Linz got together a team to explore it, and on July 17, 1910, they visited the cave entrance.

A few hundred yards inside they came across a breakdown region. An icy wind blew out of the narrow gallery, and the flames of the lamps had to be carefully shielded. The boulders on the floor were partially covered with ice. After 30 yards of low-roofed tunnels the entrance to the first ice hall was reached.

## *Ice Caves*

The floor and an enormous column in the centre of the chamber were of ice. Making their way round these, the explorers arrived at a steep chasm 90 feet deep. Georg Lahner was the first to descend the rope ladder. This is his own account: "I can still remember quite clearly the moment when I was half-way down the ladder. My amazement caused me to fall into a kind of trance, and for a few moments I did not move. Not until my impatient companions above called to me was I brought back to reality. . . ."

A small, 40-foot-high ice wall divided the ice cavern into two parts; Lahner descended into the left-hand chamber. Around him was nothing but green horizontally striped ice, glittering patches of ice on the walls; and round, smooth ice formations on the ground, broken in places by a few water holes. On measuring these they were found to touch the solid rock 16 to 22 feet below.

On August 21 the next decisive assault was made. Hermann Bock and his wife accompanied Lahner into the big pothole, and now neither of the two parts of the cavern divided by the wall of ice halted the explorers in their eagerness to push on.

As soon as the right-hand cavern had been examined, Bock looked round for possibilities of advancing further. He saw the ice draperies, the rows of slender stalactites, the iced cakes formed by dripping water, the bumpy floor and the frozen waterfalls. When he came to the ice wall, a rash and exciting thought ran through his mind: to use the wall as a bridge. With his ice pick, he climbed up until he could swing himself up on to its rim, but it was no easy task, for it was like negotiating a razor-edged ridge, which is unpleasant enough in rock-climbing, let alone in the dark and on slippery ice.

When Hermann Bock finally reached the far end of the cavern he found that the most difficult part was still to come. A mirror-smooth sheet of ice ran steeply upwards, and in this he cut step after step as he progressed.

Ahead of him lay a region of almost breathtaking beauty. He strode through enormous caverns full of ice masses, some of them like boldly conceived figures of giants, others like huge waves in an undulating glacier landscape. He stood dazzled

### *Wilderness Under the Earth*

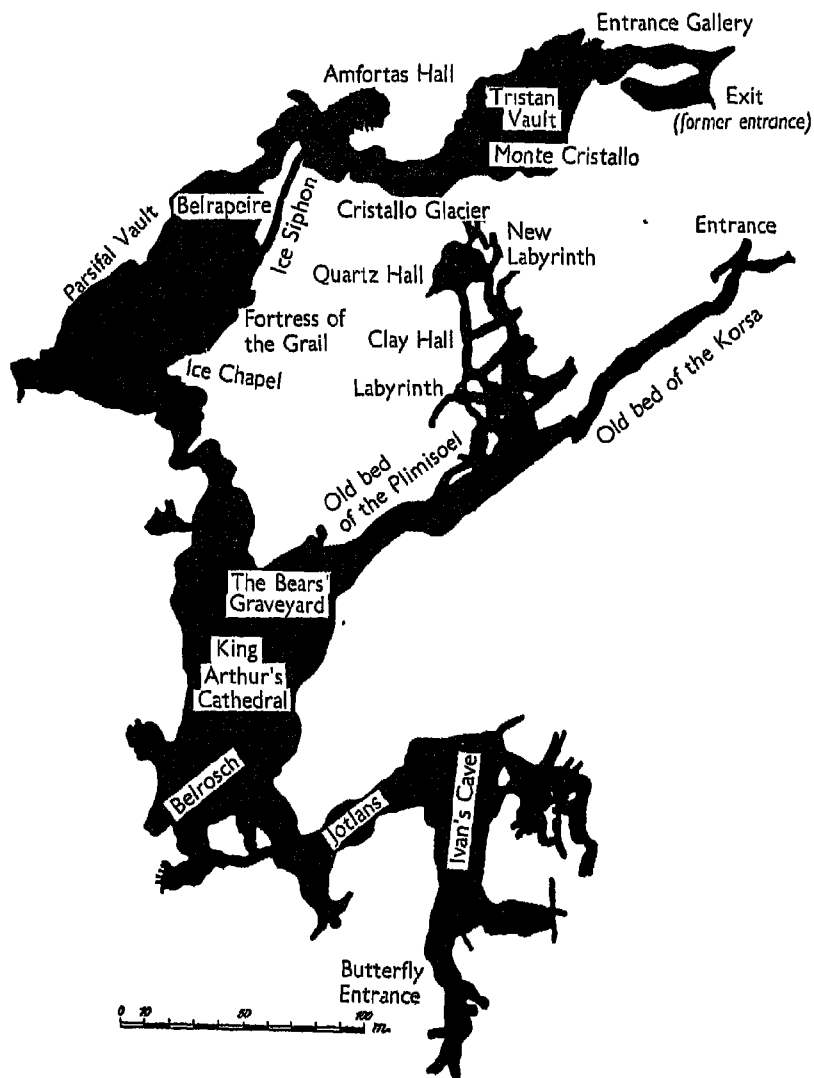
before towering ice blocks, storied galleries, arches of layered green ice, channels and milky-smooth, glittering pinnacles.

On September 11, 1910, a huge expedition organized by Bock and Lahner climbed up the Schönberg Alp in the pouring rain. Among them was Baron Rolf von Saar, the present head of the Speleological Institute in Vienna, and the young Salzburger, Alexander Mörk von Mörkenstein. They reached the entrance at about half past eight and, after a short rest, entered the mountain and made their way to the steep chasm. Hermann Bock led the way. Once more he climbed the wall, this time on a life-line, and started to cut the steps and to deepen some of those he had hacked out on the previous trip. As though watching a performance on the stage, those who remained below saw the reflection of his lamp dancing on the ice as he made his way higher and higher and finally negotiated the last few feet without a rope. On a 260-foot line, belayed on both sides of the wall, the other members of the expedition followed and then began a systematic examination of the cave. Von Mörkenstein, however, unpacked his painting materials and began to set down on paper his impressions of this imposing scenery. The discoverers christened the mighty ice palace next to the chasm, "The Tristan Vault". On the level ice floor close to the ledge loomed a sugar-loaf ice figure rising to a 30-foot high roof of reddish brown rock. A sequence of ice chambers lay ahead of the persistent explorers; they refused to be intimidated either by the ledges or the ice patches; they forgot their hunger and weariness in this dazzling wonderland.

The end of the ice stretch forms a low gallery running beneath enormous limestone slabs, "The Keyes Crawl" which Bock was the first to cross. The gigantic vault, beneath which he stood at about nine o'clock in the evening and which he called after King Arthur, seemed to stretch to infinity, and boulders as big as houses lay strewn across it as if dropped casually by the hand of some giant. While the other members of the expedition disappeared in all directions, Bock and Lahner remained behind to take measurements. Later they all congregated on a broad rocky platform, ate their provisions and drank from a shower of drips from the roof.

To-day the Dachstein Caves are the most frequented in the

## Plan of the Dachstein-Rieseneishöhle



After a map by Dr. Rudolf Saar and Engineer Potuschak  
(Theodolite Survey by the Austrian Forestry Confederation)



## *Wilderness Under the Earth*

world. A funicular railway leads up to the Schönberg Alp bringing visitors from all parts of the globe. Tourists flock among the age-old larches, the mountain hut is besieged, waitresses serve Coca-Cola and Espresso coffee and, soon, a modern hotel is to be built and the funicular will be carried up to the plateau. Seldom have the achievements of modern civilization in Europe approached so near to untouched nature. A mere step away from these amenities, overhanging cliffs tower into the sky and a few primitive tracks lead through the rocky wilderness of slopes, walls and piles of scree up to the plateau.

But inside the cave the difference is striking. Clefts open a few yards from illuminated paths—as he passes, the guide tells his flock that presumably they lead to other ice chambers—and from the laid path through “The Mammoth Cave”, by which the Anger Alp is reached, at every turn branch galleries leading into labyrinths where even to-day can be found the footprints of their discoverers. A little further and chasms are reached which have not yet been fully explored.

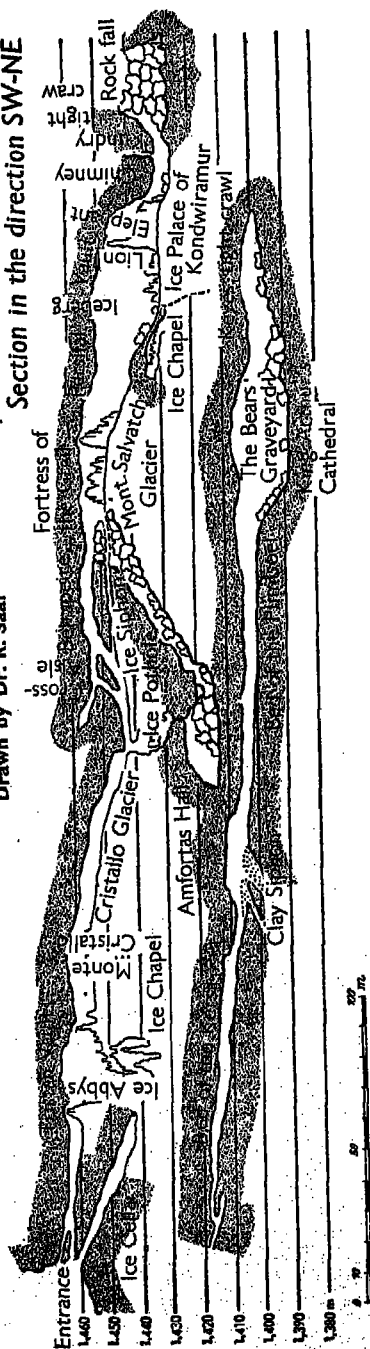
The largest ice cave in the world is the Eisriesenwelt in the Tennengebirge. It covers an area of 23,000 square yards of ice surfaces and over twenty-five miles of galleries. The entrance lies at a height of 5,420 feet. The huge, tunnel-like cave entrance is 65 feet high and almost as wide, and far into the interior can be seen reflected the bluish snow of the Hohe Tauern and the Hochkönig.

In the year 1879, the natural historian Posselt-Czorich climbed up here with a local hunter to get a view of the hidden regions behind the portal. While his companion remained outside, Posselt climbed alone over boulders and scree down into the mountain. A smoky torch served him for light. He advanced about a furlong until a mountain of ice and a vertical wall barred his passage.

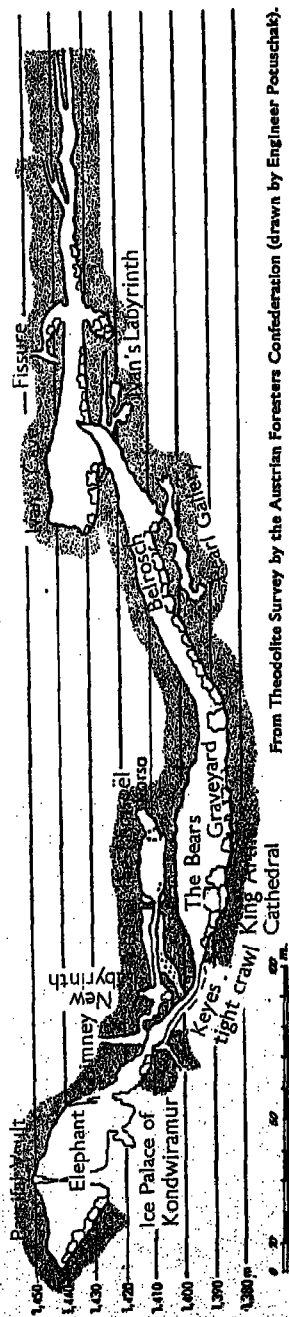
In 1912, Alexander Mörk von Mörkenstein discovered Posselt's official report in the Alpenverein Year Book, and with a few friends he followed the pioneer's trail. The pictures of the Dachstein Cave were fresh in his memory and he was fully determined to open up some of the underground ice marvels in Salzburg. But the assault had to be postponed. On the descent,

**Drawn by Dr. R. Saar**

Section in the direction SW-NE



## Section in the direction SE-NW



From Theodolite Survey by the Austrian Foresters Confederation (drawn by Engineer Potuschak).

### *Wilderness Under the Earth*

darkness overtook the explorers and they had to spend the night on a narrow ledge. In the grey light of dawn they came up, exhausted and frozen.

The next expedition followed in 1913. With his friends Angermayer and Richl, Mörk spent hours cutting steps in the ice. They did not know whether they could get any further once they reached the top; the whole wall might well be sealed in, and then their efforts would have been in vain.

The three men were lucky. At the top the steep ice fall levelled out and lines of ice pinnacles glittered in the lamp light. The explorers, mirrored in the ice floor, crossed the great chamber, and passing between two giant ice pillars they heard a distant roar like a waterfall. A storm-tossed lake could be seen. Swept by a gusty wind, the waves piled up on one side, and then surging back blocked the air-pipe; the blasting and banging which resulted was like that of an immense air-pump.

Their route was now barred, but three weeks later Angermayer, Mörk and Richl returned to the ice shore, and this time Mörk brought a home-made diving suit and slipped into the water, attached to a rope. His companions had a few anxious moments, but he finally surfaced and they soon learnt that what lay behind the ice lake far exceeded any of the hitherto explored regions.

The First World War put an end to their explorations. But by 1919 the Salzburg speleologists were back at work, although Alexander von Mörk was missing, as he had been killed in action in 1914 far from his home.

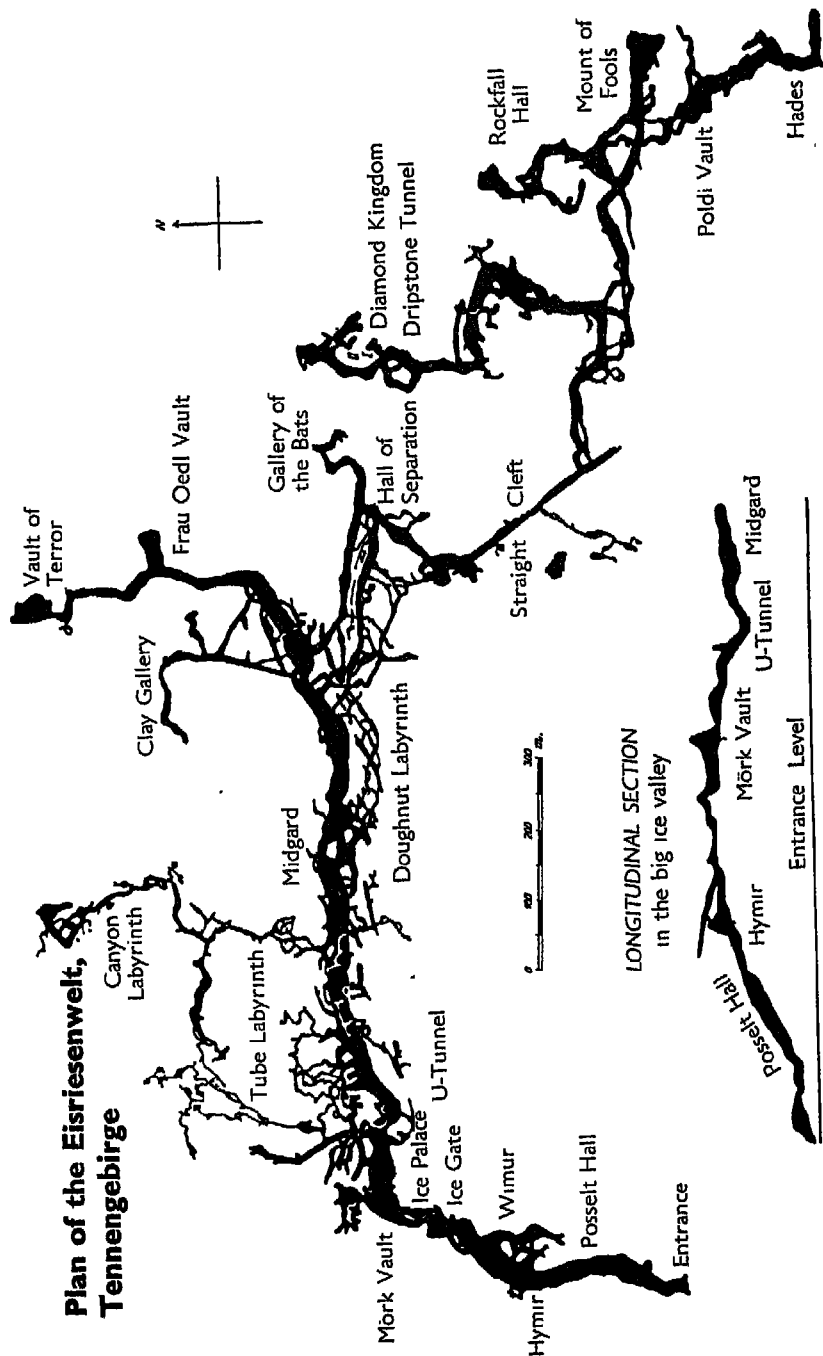
An attempt was made to divert the ice lake; after a great deal of strenuous work, the water was led into a fissure and the entrance lay open to new regions which had only been seen by one man, Alexander Mörk; it was as though destiny had given him this last glimpse as a gesture of compensation.

Like fairyland castles, ice towers rose between the roofs and walls; one hall—a vast, incredibly silent cathedral—was called “The Alexander von Mörk Vault” in honour of its fallen discoverer.

\* \* \* \* \*

The presence of enormous ice masses in the underground caverns of our Alps obviously has a close connection with our

# Plan of the Eisriesenwelt, Tennengebirge



## *Wilderness Under the Earth*

climate and in particular with the temperature. Long-term and accurate figures have proved that in regions far below the surface a constant temperature reigns depending on the height above sea level and the latitude. This constancy led persistently to contradictory theories of temperature conditions in caves. On his descent deep into the earth in the summer the caver has an impression of icy cold—because the surface temperature at that season is considerably higher than the average yearly temperature—but in the winter the interior seems pleasantly warm because the temperature outside is far below the average yearly temperature.

The first theory of ice formation in caves was built on this error. According to this, ice formed in the summer months, while the melting and disappearance took place in the winter. Until the end of the nineteenth century this theory could be justified, although at the time a conflicting view, the theory of winter ice, was championed. In order to see the conditions in their right perspective, speleologists had to excavate further and observe more accurately the climate of caves.

I have already mentioned the wind which blows through the underground systems, describing it as an element friendly to humans because it betrays the places where a continuation can be expected. Moreover, it brings fresh air into the cave. I have never suffered from lack of air even in the deepest parts of the huge cave systems in the Alps, although in many draughtless caves the air is damp and sticky, and after a few minutes one gets a headache; it is days before the pressure on the head disappears. To look more closely into the original causes of wind movement and absence of wind, we must differentiate between caves with a single entrance and those with two and more. Why? Some people might think that there could be no air draughts with a single opening. Where could the air flow?

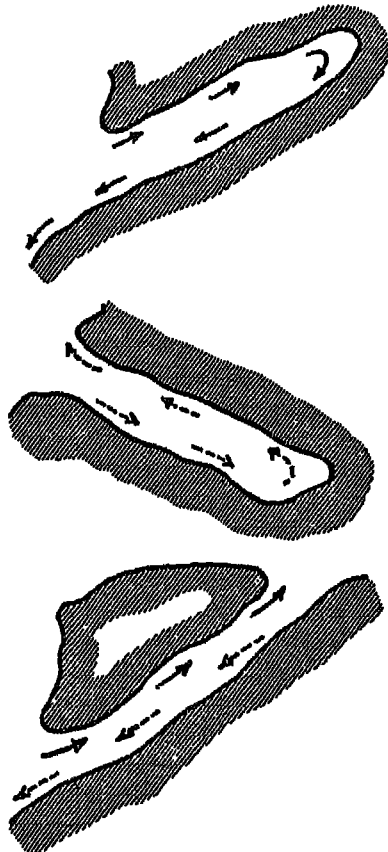
The facts, however, are not so simple. Air can flow perfectly well even if it only circulates, i.e. outwards in the vaulting and inwards over the floor. But how can such a strong current come about?

The motive force is provided by the variations in temperature. Without these there would actually be no draught, but they are usually great enough to circulate the air. Let us

## *Ice Caves*

consider a tubular, "statically ventilated" cave for our experiment, something in the nature of "The Stove" in the Schönberg Alp, a tunnel leading in a straight line from the entrance and coming to a dead end. If a fire is lit outside, what is the result? The colder, and therefore heavier, air inside will flow out below, and the warm and lighter air will enter and remain near the roof. In theory the whole of the cold air should now disappear and the warm air fill the room: the difference in temperature would be cancelled out and the movement come to a standstill. But this is obviously not the case, for the cold rock in which the cave is embedded must be taken into consideration. It draws off the warmth from the incoming air without itself becoming noticeably warmer—this is because a given volume of a solid will absorb more heat than the same volume of a gas to produce a rise of temperature of say  $1^{\circ}$  C. The cooled-off air then sinks from the roof to the floor and streams out again. In the meantime the inflow of warm air continues and the circle is repeated, with little interruption throughout the entire summer. The limestone meanwhile has stored up important masses of heat energy.

Then autumn comes and eventually winter; now the outside air is colder than the air inside the cave. Does the warm air now stream out to make room for the cold? By no means. The light warm air fills the cave but cannot get away, for the outside air is heavy and



### *Wilderness Under the Earth*

refuses to leave or rise. In winter, therefore, the cave remains warm—hence its name, “The Stove”.

The opposite applies to statically ventilated caves which run downwards—the so-called “sacks of cold”. If we transpose the above conditions it is easy to account for this name. Whereas in winter the light, warm air flows unhindered into the open—during this the cold air constantly sinks, repeatedly heating itself and rising to the roof on the outward return journey—the cold summer air lies above in the cave like static water. The warm air cannot enter and the cold air cannot leave, and now will be seen the connection with the original problem which we do not appear to have approached—namely, the problem of ice caves. It is clear that a “sack of cold” is an ideal refrigerator for cave ice. This actually also applies to caves the average yearly temperature of which, according to their locality, should lie above freezing-point. Inflowing melt-waters freeze in the winter months and continue to do so far into the spring, and in summer the entrance is barred to the warm masses of air. Naturally warmth penetrates through fissures and clefts and even through the rock itself, but it is insufficient to melt the ice to any considerable degree.

The formation and preservation of ice in statically ventilated caves is thus satisfactorily explained. But our largest and most beautiful ice caves, the Eisriesenwelt, the Eiskogel Cave and the Dachstein Rieseneishöhle, do not fall into this category, and therefore we must consider the other types, the dynamically ventilated caves.

Take the example of an ideal “corridor cave”, i.e. one that constantly runs upwards without traverses, for in principle the results will also apply to complicated cave systems. The air, warmed outside by the sun, will become lighter as opposed to the air inside the cave. The balance is disrupted, the cold air runs out below and the warm streams in above. Once more in its course through the cold chambers of the cave it will lose a great deal of its surplus heat. At the lower entrance it will already have reached rock temperature and flow through the lower rooms as a comparatively cool draught. Any ice masses that happen to be present will therefore last through the warm season comparatively well.

## *Ice Caves*

Now let us look at the winter conditions. Should these also create favourable conditions for ice in the lower regions, then the masses of ice in large ice caves are no longer a mystery. For in them the frozen sections actually lie nearest to the lower exits. We do not know the upper entrances of any of these three large ice caves, but we have a clue from the air circuits which continually blows through the galleries: they are the lowest regions of dynamically ventilated caves.

In the winter the outside air cools fast. The considerably warmer and lighter cave air rises as in a chimney and the cold winter air penetrates from below. If, in actual fact, it slowly warms as it rises and reaches the top considerably warmer, this merely serves to keep the flow in progress and our theory is proved. We can imagine how the icy air of the mountain winter ruthlessly freezes the inflowing percolating water. In this way is born the most beautiful adornment of our caves—ice.

It can assume a host of forms. A rough differentiation can be made between seasonally formed ice, which melts in summer and often reforms in a new garb in winter, and permanent ice. While the constantly re-transformed ice mostly becomes club-shaped or fringe-like, beautifully branched icicles, permanent ice is usually in thick lumps. Transparent layers, in which the natural blue-green colour of ice glistens full of tiny air bubbles, constantly change and decorate the cold glassy masses with a pattern of stripes.

\*       \*       \*       \*       \*

I arrived at about seven o'clock in the evening at the hut on the Schönberg Alp. Dr. Hubert Trimmel and Helmut Fielhauer were waiting for me.

"There will only be the three of us," said Hubert. "The others have called it off because of the bad weather. It's doubtful whether we ought to make the trip."

It had rained almost continuously for three weeks and flooding catastrophes had been reported from all over the country. But since that day the weather had cleared, I replied: "Let's sleep on it and see how things look to-morrow morning."

They both agreed, and we opened the two cases from the Vienna Speleological Institute, which had provided us with



## *Wilderness Under the Earth*

material. We unpacked nylon ladders, pitons, ice-picks, mountaineering shoes, a heavy life-line, canvas, air-filled mattresses and similar articles of equipment. They would be of great use, for this time our goal was an ice cave on the Dachstein Plateau. Hubert, on a tour with Dr. Fridtjof Bauer of the Vienna Speleological Institute, had discovered it the previous year.

We set out the following morning. The hut-keeper wished us luck and told us to be careful; at Easter thirteen students had been killed on the plateau and only a few weeks before a man had gone climbing on his own and had never returned.

"We shall take care of ourselves," we replied and were soon climbing the ladders leading up the steep slopes. We were heavily laden and, after a few minutes, bathed in sweat. We continued our steep climb to the Upper Schönberg pasture, with its ruined huts, and through plantations of dwarf pines. Eventually we reached the Almberg and a few steps from its peak yawned the 26-foot wide hole leading to the Western Almberg ice cave. There is also an Eastern Almberg ice cave and we wondered whether there was a communication between these two.

Before we started work in the cave, we took a bearing from the peak to the entrance for the purposes of our map.

From time to time a breath of icy wind blew up from the hole. We put on our warm clothes—pullover, mufflers, gloves, and, of course, our caving overalls—and climbed down the three 6-foot high, precipitous steps from which a scree slope leads to the ice. We entered a broad 65-foot long hall, partially filled with snow which at the far end had turned to ice.

The previous year a gallery had been discovered to the west leading down into the two potholes; after a few windings through a narrow fault it came out in a boulder chamber with a continuation. It had been filled with water and was an insuperable obstacle. This was the great and exciting mystery of the cave. We intended to force a passage if possible with the aid of two rubber mattresses to be used as a dinghy.

Hubert led the way over a steep slope of firm snow. He cut a series of steps with his axe, and we followed them down into the rock-fall chamber. Slowly the light from the entrance hall

## *Ice Caves*

faded and we had to use our lamps. Hubert steered us to a spot where enormous boulders rose out of the ice, for by using them as stepping stones we hoped to reach the ice at the back of the chamber more easily. Here only the deepest spots between the boulders were frozen, but a glistening, draped curtain of ice flowed from a bedding joint ten feet above the ground.

The source of the stream was not far away. I scrambled down carefully over the looser blocks and lit up the floor, which did not seem to be filled with water, but with ice, which broke when I trod on it. I sank to my ankles in a slush of broken ice and water. Here neither our ice shoes nor the air-filled mattresses would be of any use. Should we be forced to turn back?

On the right wall I noticed a small sloping strip; it began 6 feet behind the entrance to the stream, but a rocky buttress stood in the way, a forbidding obstacle. I could not see how it could be overcome. Bending forward as far as I could, I illuminated the rock surface, but not a cleft or a handhold could I see. We should have to rely on the clinging powers of our clothes. I let myself slide sideways on the steeply inclined surface and skated slowly towards the strip. After a few anxious moments I got a foothold, but was unpleasantly surprised to find that it was iced. I stamped my feet until I found a spot which could be trusted. Holding on to the wall with my right hand, I stood on one foot. Now I had to put the other foot forward carefully; I advanced gingerly as though walking on eggs. Six feet below me, the frozen water reflected the flickering flames of my lamp. This dangerous catwalk led to a broader ledge which sloped down to the ice. Behind me I heard a rustle—Hubert was beside me on the ledge. The ice crunched beneath his feet.

Our way continued straight ahead. The walls rose vertically, making a traverse impossible. Our only solution was to cross the ice. Hubert put one foot on it with his whole weight; it held.

It was inadvisable to continue without a life-line, for the ice surface now sloped steeply downwards. The slightest mistake and you would slide away with increasing speed into unknown depths.

### *Wilderness Under the Earth*

"Bring the rope with you, Helmut," Hubert cried to our third man as he himself turned back along the ledge to meet his comrade and to give him a hand.

I looked round for a belay, and a large boulder, deeply encrusted in ice, caught my eye. We secured the rope round it, and Hubert, who maintained that, since he was the lighter, the ice would hold him better, slid forward and disappeared into the darkness.

I felt my way forward along the rope in pursuit of him.

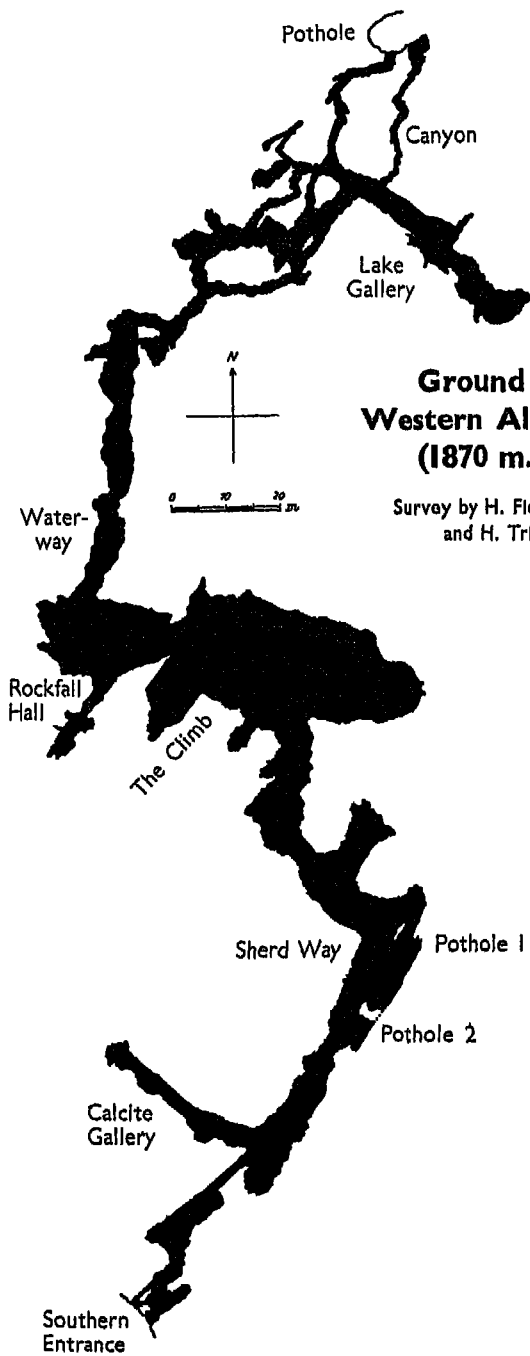
The surface here seemed to be firmer, but I soon reached a treacherous part and broke through into the water. But what did it matter that the water got into my shoes—within my reach glittered two huge ice pinnacles that seemed to be made of glass, and ahead of us lay the secret of unexplored regions. I slid further and managed to reach the ice-free patches on the left side of the gallery. Here we could stand upright and continue without the rope. Passing some of the niches I drew closer to the reflection of Hubert's lamp, for by this time he had arrived safely. And now I was at his side. . . . We had reached a spot where the chamber broadened out into a tube-like cul-de-sac. With the exception of our landing, the whole floor was covered with ice—not a smooth surface but one finely chiselled with grooves into a mosaic of diamond-shaped pieces. From the centre of the chamber, like the supports of a canopy, two solid ice columns rose from the floor to the ceiling. The majestic calm of this ice palace was astounding us. By this time Helmut had joined us, and we stood there in silent admiration.

There was only one fly in the ointment; the watercourse had obviously come to an end. In the background the ice disappeared into a horizontal cleft at floor level—not an inch of space left free.

"I can't believe that it ends here," said Hubert. "It must continue beyond the frozen sump." He pointed to a hole on the opposite wall. "We must try and get over there. It's merely a question of how to cross this watery ice."

I shook my head dubiously. The 10-inch high, 16-inch broad opening did not seem very promising, but naturally we had to explore every faint possibility.

I suggested that we should put some large rocks into the ice



**Ground Plan of the  
Western Almborg Ice Cave  
(1870 m.), Dachstein**

Survey by H. Fielhauer, H. W. Franke  
and H. Trimmel, July 1954

## *Wilderness Under the Earth*

to make stepping-stones, but first I wanted to photograph the chamber in its original state. I asked Hubert to pose at the edge of the ice to give the picture some animation and, retreating a few steps, made the necessary preparations. Setting up the camera on a small aluminium tripod, I chose the picture I wanted and secured the flash equipment in a side niche. At last everything was ready; the shutter was opened, the flash went off and Hubert was able to rise from his uncomfortable position. Just as he was stretching himself, there was a rumble, a dull thud and a boulder weighing at least a hundredweight crashed at the exact spot where he had been sitting. It bounced over the ice and sank in deeply.

The boulder had providentially made the first stepping-stone for us on the ice. I stepped on it and found that it was firmly embedded. Hubert handed me a large fragment of rock, which I threw a yard ahead of the other boulder; a few more fragments of the same size and we should be able to make the crossing.

Hubert could not control his impatience. While I was carrying the last rock he ventured on to the ice surface and reappeared in the opening below. His legs disappeared and I expected that any minute he would return with a look of disappointment on his face, saying that the tube was an impasse.

But he did not reappear. A sudden feeling of conviction encouraged me to take the decisive step. I followed him, squeezed my way into the opening; my knees bored into the spongy mass of ice, but my head was soon beyond the squeeze. The cleft was still narrow, but it gradually broadened out and in the light of my lamp I could see a frozen waterfall beyond the sump. I crawled forward on all fours; a thick layer of hoar frost twinkled overhead. The ceiling rose, but the chamber narrowed and the ice filled its entire breadth. Hubert must be somewhere ahead, although I could no longer hear the sound of his footsteps. The passage divided into two broad forks, and I followed the left-hand one, which branched off once more to the left. This feeling of ownership was superb—the conquest of a mysterious no-man's-land without bloodshed. I paid less attention to the way than usual: I slid forward, fell, picked myself up again. . . . What did a few scratches mean in

## *Ice Caves*

comparison with this surge of new impressions, this unique experience? I joined Hubert. The ice grew sparser; thick loose piles of gravel gave some trouble. To the left was a trench meandering through the gallery. We jumped from rock to rock; a large block toppled before my foot had left it; the floor was soft underfoot—clay, sand or gravel, dark material that rose ever higher until it reached the roof. We took a rest to collect our thoughts, and it was then that we suddenly remembered that Helmut had not followed us. I glanced at my watch and saw it was high time to turn back.

That day we had abandoned ourselves completely to the joy of discovery, but on our next visit the way must be measured yard by yard, sections must be drawn, observations recorded and the side passages examined.

Our scientific exploration of the West Almberg cave occupied us for several days. Although the extent of this newly-found region was gratifying, the surveying which followed was wearisome.

It needed hours to survey a mere corner of the main stretch. Now, in this slow activity, we were subject to the cold. When penetrating into the innermost part we could not avoid the water seeping through our clothes and shoes; as we crawled over the ice, the surface thawed and the material of our overalls—particularly at the knees and elbows—became waterlogged; as soon as we stood still, we steamed like a tea-kettle. Nevertheless, we had no cause for complaint. In many caves it is unavoidable that you should get soaked—for example, in the Ötscher Pothole, or in "The Rain Pitch" of the Tantalhöhle.

The worst obstacle is when there are deep stretches of standing water. Gustave Abel goes in fully dressed. If afterwards you continue to move about, your clothes dry of their own accord and no damage is done—that, at least, is what Gustave Abel maintains. And who am I to contradict such an experienced caver?

Alfred Koppenwallner once tried another trick. He smeared his skin with a thick layer of grease and tried to swim through a subterranean lake, but he was not very satisfied with the result

### *Wilderness Under the Earth*

of his experiment. The body freezes in a flash when it is unprotected from the cold and movement becomes impossible, so what is the use of having dry clothes later when there is a danger of your drowning in the cold water.

In comparison with such icy baths our wet elbows were harmless enough and we did not allow ourselves to be discouraged. Furthermore, the monotony of the survey work was not too depressing, for we were forced to examine all the side ways, where many a discovery might have awaited us.

One of the unsolved problems was a canyon in the innermost parts where the sand deposits occur. I climbed down 23 feet on my own, using chimney technique, though in places I was helped, for the walls were covered with sharp rock ledges which I could descend as a staircase; the water had left them in its downward excavating course, but they were often so thin that they split off underfoot.

I did not quite reach the bottom of the canyon, because it was too narrow, so next I followed the watercourse upwards, soon reaching a narrow, impassable fissure from which the gravel poured. The other direction now looked more promising, so I tried that.

Hubert followed me. Progress was tiring. The canyon gradually narrowed and we had to gain height. Each time we scraped the rock the sharp edges ripped our overalls to pieces.

A right-angled bend. . . . The space broadened out a little and I decided to wait there for Hubert, who had fallen behind. There was no sound. I called down into the canyon, which gaped at my feet like a twisted mouth full of teeth—the teeth, of course, being the jagged rocks.

"My lamp's gone out," I heard him say at last. There was a rustle and a sound of clawing. I knew that he was feeling his way towards me in the dark.

"Wait," I cried. "I'll come and meet you." I lit the way for him as far as the bend, which was roomier than the rest of the stretch, and here we tried to relight his lamp, but the carbide was exhausted. Helmut had a supply outside the cave, but we had no time to make the return journey. Since we could not both climb into uncharted regions with a single lamp, Hubert

## *Ice Caves*

had to remain alone in the dark, so he settled himself in the rock and I went on ahead.

The canyon narrowed again immediately. From time to time I looked at my wrist compass and plotted out the stretch behind me. To make a survey here would probably require a half a day, and we still had enough to do on the main stretch, so could not waste much time. However, I wanted to make a rough plan.

A few yards to the north, then a slight bend to the left. . . . I slowly lost height. I had to take special note of the altitude, otherwise on the return journey I should descend too deep or climb too high and finally get stuck in an impasse.

Ahead of me I heard a muffled booming, quite different from the babble of the little brook below me. The canyon came out into a broad, dark chamber, and 10 feet deeper I found a horizontal ledge. I wondered whether to risk a descent. A slight act of clumsiness, the lamp had only to slip out of my hand at a dangerous spot, and I was lost.

But this large, exciting chamber ahead of me! Taking the utmost care, I hoisted myself out of the canyon—it was a very difficult piece of climbing, for the water had eroded a deep, narrow slit which allowed an arm or a foot to be stuck into it while the body remained free outside. At last I stood, panting heavily, on the down-sloping step, and when I lit up the darkness below me I found a small sloping platform masking my view. Once more I scrambled down the side wall.

I swore, for below me was another ledge. This time a descent would have been folly. The rock face was smooth, without hand-holds, and the floor below was even but on an incline. I tried to pierce the darkness. I managed to recognize that I was in a niche-like chamber into which the canyon debouched, but I could see nothing of the terrain ahead. The sound of falling water came to my ears. A cold, gusty draught cooled my hot cheeks with a blast of fine spray. I looked round for a piece of rock to throw down—perhaps I could at least estimate the depth—but could only find a small pebble. I heard it hit once and then silence. The din of the water was too loud.

Nothing remained except to turn back. The lower ledge was easily negotiated, but the second caused me great difficulty.



### *Wilderness Under the Earth*

With my back against the wall, braking with my feet at an angle of  $60^{\circ}$ , I had to slip from above into the canyon—from a higher point than I had reached on the outward journey. I had been able to check my progress against countless projections on the wall—but on the return trip I had none of these at my disposal. I had almost reached safety when I heard a ripping of my overalls; I had caught them on a jagged spur. I wriggled back into the big chamber; once more I raised my knees until I was horizontal in the corner, then I slid unhampered head first into the cleft. Now I was safe, although I was standing on my head with my legs in the air.

Hubert had not stirred since I left him. I took a short rest and, in order not to waste time, prepared to take a flashlight photograph of Hubert starting on the return journey.

Now we had to be careful not to overlook the right place to begin the ascent. In any case, we should not have got into trouble, for we could hear a dull thud of stamping feet, which could only come from the upper gallery. We clambered up quickly, and surprised Helmut in the act of doing a Red Indian dance to keep himself warm.

Our survey work progressed. A side passage attracted me, and I went into it, bent double. The cries of my two comrades calling out lengths and angles followed me inside. A couple of similar side galleries, after a few windings, had returned to the main system, and I thought that this one would probably prove no exception, although it seemed to run in a different direction. I heard a dull sound, and suddenly the void lay ahead of me—no walls, no roof, no floor. My path ended here, half-way up a pitch. Something moved under foot; I was no longer on firm rock, but on scree and boulders which lay loosely piled up at the edge of the abyss. I jumped back. Some of the fragments came loose and hurtled downwards. I counted to five seconds before I heard the first thud—that meant a depth of 160 to 200 feet—and then a rumbling which gradually died away.

With the utmost care I climbed on to a small ledge on the wall of the chamber. I could not distinguish the smooth wall opposite; below and to the right of me was impenetrable darkness. The water splashed down from above and a fine spray

## *Ice Caves*

lashed my face. I was convinced that I had hit upon another side of the chamber into which the canyon had also brought me.

This gigantic pitch in the innermost part of the cave, joined to it by only a narrow gallery and an impassable canyon, in my opinion, meant another system, the lower storeys of which lay down there in the depths. It would have been very promising to make a descent, but there were only three of us with 100 feet of wire ladder. We had to renounce any idea of an assault on these unknown, intriguing depths.

We still had two days' work in the Alnberg Ice Cave. The southern part had to be surveyed, in addition to a horizontal slit at the back of the entrance hall into which the ice disappeared. At one spot it seemed high enough to slip through. Hubert took me on the rope with a firm stance on a boulder embedded in the ice. I wriggled my way slowly into the slit and pushed my head through. Immediately behind the squeeze the ice fell away with a 45° drop.

"Can you let me slide down slowly?" I asked.

"Yes; we'll hold you," replied Hubert. "Have a shot."

I slowly pulled myself forward by the rocky roof, the lamp in my right hand and an ice pick in my left. Only once did I look back. Through the cave opening the sunlight streamed on my friends, turning them to statues on the boulder, clutching the rope with both hands; with the light behind them, they were outlined in brilliant gold. I let my weight take me over the step, but instead of sliding down slowly on the rope, I began to gather speed and sped like an arrow into the mountain of ice. I no longer knew which was "up" and which was "down". A sudden jolt and the rope tightened painfully round my waist. I had to collect myself for a moment. My lamp had gone out, but I was bathed in a marvellous pale green light. The whole icy cavern reflected this light—it was caused by the sunlight, broken many times, entering the ice mass outside and filling this room with indirect lighting.

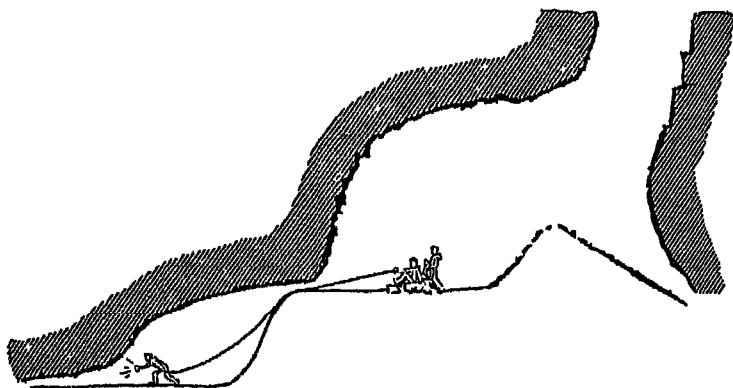
Now I could hear the call of my comrades.

"O.K.!" I shouted back. I could now see where my involuntary descent had led me. Close to the gently sloping ice surface, over which I had thought to slide down slowly, was a bank which fell steeply until it became an almost vertical wall of

## *Wilderness Under the Earth*

ice, and my body, secured to the rope, had slipped sideways on to this. The rope had followed my movement and had been drawn along the broad entrance cleft into this narrow side passage.

I stood up to examine the back of this ice chamber. First I asked for my satchel; Hubert attached it with a karabiner to the rope and lowered it down to me. Still on the rope I made my way cautiously to the back of the chamber. The ceiling lowered; I stood in an ice runnel but after a few steps the roof



descended to the ice floor. Since there was no trace of an extension I notified the others.

"We'll pull you up," called Hubert. I had my own ideas about this, but to cut steps in the ice slope would have wasted too much time.

Soon I felt myself being hauled up and was swinging to and fro on the icy surface. Obviously they had to pause for breath, for they left me hanging while regaining their strength. A tug and my journey started again. Soon I was sliding over the hump of ice. Ahead of me lay the cleft. I knew that I could still pass through 10-inch squeezes, but this particular cleft must be even narrower. I was soon stuck. My centre of gravity lay beyond the abyss, but I could at least push my satchel and the lamp through.

The men on the rope took another rest. The water ran down my sleeve.

"I don't think I shall ever get through here," I kept muttering between my teeth.

## *Ice Caves*

"Let's try again," called Helmut. They began to heave on the rope. I was flapping like a fish in a net and felt that I was being passed through a mangle. At last I realized that my head and shoulders were through. The rest was now simple.

"Stop," I cried. "I'm through." But they were so preoccupied in their work that they kept pulling and I sped over the ice like a toboggan throwing up to right and left a wake of spray, for in the meanwhile the sun had thawed the ice. Eventually I came to a stop with a thud against the boulder on which my friends were standing.

Now the major part of our task was finished. A short survey in the southern part and we could safely make the last descent home. An hour later, when we came out of the southern entrance into the shakehole, we were met with a pallid yellow light. Wisps of mist floated over the snow slopes. Outside there was a dull, disturbing rumble. We climbed the three steps to the edge of the entrance, only to find a beautiful but at the same time very alarming spectacle. A bare 15 feet above our heads was a thick greyish-yellow cloud and from time to time a flash of lightning in the eerie twilight lit up the limestone slabs. In the distance, however, towards Hallstatt the sun was still shining; through the mist we could see the lake; the slopes were spectrally bright, for the low-lying clouds acted as a canopy.

But we had no time to stay and watch this magnificent display, for the clouds were sinking visibly, and we had to get away from this dangerous thunderstorm as soon as possible. We hurried down the path, jumping over deep gullies, tripping over tree roots. And then the first heavy drops of rain fell.

The flashes of lightning grew more powerful and the thunder claps followed in quick succession. Our metal equipment could prove dangerous. A few wreaths of mist were on the point of enveloping us, when at last we were off the plateau and began to lose height rapidly. The rain poured down, but by this time we had reached the entrance of the Dachstein Rieseneishöhle on the Schönberg Alp. A few moments later we were sitting in the empty hut. The weather had driven away the last visitors to the cave.

## *Chapter Eleven*

### EXPEDITION TO THE GELDLOCH

THERE ARE CAVES which offer no particular difficulties to their explorers and can be combed down to their last nook and cranny in the course of one tour. But there are others which, like obstinate beasts, refuse to be tamed and put up an endless struggle without ever completely succumbing to men.

The Geldloch in the Ötscher in lower Austria must be numbered among the latter. Old legends speak of dark vaults in which gold and treasures were purported to be hidden—this gave the cave its name, and incidentally one of the inner rooms is known to-day as “The Treasure Hall”—in it were found the remains of primitive hewing and digging implements, and also bones of unfortunate treasure hunters who never found their way back to the surface.

The first systematic visit took place on December 6, 1591. On orders from the Emperor Rudolph II, the lord of the manor of Freideck, Reichard Strein, as Imperial Commissioner, accompanied by the standard bearer, Christoph Schallenberg, a servant from the Gaming Carthusian Monastery, Hanns Gasner, and eleven porters, climbed the Ötscher. Their visit to the cave lasted three hours without their having reached the end.

In the autumn of the same year, the Prior sent Hanns Gasner with a few companions once more into the cave “to see whether perhaps this time they could find an exit at another part of the mountain”. Gasner climbed up the wall which to-day bears his name and reached the end of the left gallery; a noteworthy achievement, for “The Gasner wall” ranks as an extremely difficult climb.

Subsequently, small groups visited the cave every few years.

## *Expedition to the Geldloch*

Systematic surveys with photographs and geological observations were made under E. Berr and H. Hassinger in the years 1900 and 1902. A pothole in the right branch of the cave proved to be particularly difficult indeed; it was declared impassable in 1855, but the uppermost sector was penetrated.

In 1921 a series of explorations were undertaken, and other well-equipped expeditions followed in the succeeding years of 1922, 1923, 1927, and 1948. A depth of 1,230 feet was reached by Captain Lechner, but this was certainly not the bottom of the Ötscher, which presents such extraordinary difficulties to the caver and makes very great demands upon him.

\* \* \* \* \*

12.1.52. At the Annual Meeting of the Vienna and Lower Austrian Caving Clubs there was a feeling of great expectation. The small cellar could not hold everyone, but a number of the old members, many of whom appeared very rarely, were present, including Lorenz Lindenbach. Soon the moment arrived for which everyone had been waiting, and Lorenz Lindenbach, calling for silence, put forward the motion that a large expedition to the Ötscher Pothole should be arranged. The goal of the expedition was to be a complete exploration of the pothole to its lowest depth. A committee, with the help of the active members, should make the preliminary preparations.

The repercussions were heavy. The members split into two groups, one for the proposal and one against. Dr. Salzer led the second group.

"The Vienna Club," he said, "possesses neither the means nor the men to enable it to be carried out."

Dr. Trimmel was not very enthusiastic, but was of the opinion that if all the Austrian cavers co-operated a satisfactory result would be reached. Most of those present agreed with him, and Dr. Salzer resigned his presidency of the Club. Thus preparations began on this courageous though risky project—no one could say if it were feasible—the ultimate exploration of the Ötscher Pothole.

1953. The preparations for the big expedition which began on July 5 lasted a year and a half.

This time I did not arrive from Vienna like the others, but

### *Wilderness Under the Earth*

from Nuremberg, and had a tiring night journey behind me. Nevertheless, my weariness vanished as soon as the pretty little Mariazell railway train which was carrying me up into the highland came out of a long tunnel and gave me a view of the Ötscher.

A six hours' climb—a tiring, sweating march through mosquito-infested undergrowth, time wasted looking for washed-away direction marks, endless tramping over terraces, up zigzag tracks to the clearing above the dwarf pines, the scree slopes and finally the buttress where the way forked into the cliffs. Up to the peak above "The Rough Crest" and then to the left, skirting the walls to the cave.

Even now I was afraid that the expedition might have been called off at the last minute—I had not met a soul since the last hut—but now I could set my mind at rest. I still could not see the cave entrance, but as my eyes followed the path, the second approach to the Geldloch to the valley below, where it disappeared among the tress, I noticed at irregular intervals of 10, 100 or 200 yards single men or groups moving, small as ants at this distance. They were carrying heavy loads. It must be a giant expedition, I thought.

I hurried over the scree slopes towards the goat track, a bend, a few more steps and there in front of me was the gaping entrance to the Taubenloch, a 100-yard long, blind cave. Here I found a couple of acquaintances—Heidrich, who had taught me to use a nylon ladder in the Bodenberg potholes—his mop of hair still waved in the wind, but it had now turned grey—and Albert Morokutti, my indefatigable companion from the Tantalhöhle. While I was exchanging a few words with them, one caver after another climbed up the path and let drop his pack—Karl Wiesler, who had once revealed to me the secrets of the Lur<sup>1</sup> Grotto, Hubert Trimmel, my old comrade of so many tours and adventures, Norbert Zernig from Graz, a companion of strenuous days on the Tauplitz plateau, and many other old faces: Alfred Koppenwallner, Dr. Fritz Oedl, junior, Dr. Fridtjof Bauer, Helmut Fielhauer, Franz Wallisch, and his wife, Anny, Frau Heidrich, known as the "flittermouse", and Fräulein Tönies, the ladies who look after the "inner man".

I descended with Karl Wiesler to the Jagerherz hut, where a

### *Expedition to the Geldloch*

great load of material had been stored, waiting to be brought up for use in the ice chambers and in the pitches.

Wiesler gave me a rough sketch of the details. Apart from the members of the Caving Club who would carry out the active work in the cave, there were represented the Austrian Alpine Club, the Mountain Rescue Service, the Vienna Institute of Meteorology and Geodynamics, and the Vienna Speleological Institute. The most important work, the descent of the potholes, was to be undertaken by two advance teams, the mainstay of which was the Tantalhöhle team: Koppenwallner, Morokutti, Ginzinger, Dr. Oedl supported by Zernig, Wiesler; and Trimmel, Wallisch and myself. Our routine would not be known until later.

When we returned with the ladders to the cave entrance which lie ten minutes apart in the south wall of the Ötscher, we found tents pitched in front of the Geldloch and the Taubenloch. Between two boulders in the Taubenloch the women had installed a field kitchen, and tea was already steaming in a kettle the size of a baby's bath. Night fell outside. A host of carbide flames lit up the broad chamber of the Taubenloch antechamber. Each movement threw shadows on the wall and voices echoed from the rocky roof and walls.

A few wisps of mist penetrated the caves, bringing a damp, cool current of air in their wake. People began to put on warm pullovers, while others rolled themselves in their blankets and drank a quick cup of tea before retiring to sleep. I took my sleeping-bag into a far corner and stretched it out on a moderately even patch of scree. Gradually silence fell. At regular intervals, drops splashed on the floor: one could count the seconds and know exactly the moment when the next one would fall from the roof. From the field kitchen came the conversation of the tea-drinkers. One lamp after the other died, until only a few eerie blue flames remained to give the cave a ghostly aspect. I noticed little, for I was beginning to feel the effects of my previous night in the train and sank into a deep, dreamless sleep, from which I only woke the following morning when the activities began.

I had slept through one thing: it had rained in the night, as was unpleasantly obvious in our sleeping quarters from the



## *Wilderness Under the Earth*

increase of dripping water. Here and there regular rivulets trickled down, and most of the sleepers had been driven to look for a new resting-place. The sluices had opened over my head too. As soon as I woke up I had to pull my head back in my sleeping-bag, because I received an unwelcome shower from above.

This day was spent in preparations, and I tramped with Hubert to the Geldloch, where the Mountain Rescue Service had pitched its tent. Great activity was evident in this deserted corner of the earth; below the overhanging walls rolls of ladder lay piled up; Heidrich was there cleaning and filling the carbide lamps; one group had chosen its quarters on a horizontal platform formed by a boulder as big as a house; the telephone post was also installed here; a team had worked throughout the night laying a line to the edge of the pothole.

Even outside the entrance the icy breath of the mountain could be felt; almost without transition, we passed from warm summer air to between 2° and 3° C.

We put on our overalls and followed the telephone wire. A gigantic tunnel 125 yards long and 130 feet deep led down to the deepest point of the horizontal section—as far as the ice lake, which was shallow that day and easy to circumnavigate. The daylight reached as far as this, turning the ice surfaces and the blocks of ice to blue. The water of the lake was unruffled and beautifully clear, and anyone who was not paying attention would not have noticed it until his feet got wet.

Passing over a few ice-terraces, we reached "The Ice Vault", an immense hall with a flat, frozen floor, with hillocks and cubes of ice and one particular formation characteristic of the Geldloch—the ice balustrade, a wall with ice pinnacles running the breadth of the whole chamber.

Here the way forked. The left branch led to two narrow passages, "The Windholes" over "The Debris Hall" and "The Wild Hall" to "The Gasner Wall" from which the boulder fall at the end is reached through a hall with dripstone formations. We took the right-hand fork and strolled leisurely for a while until we had to negotiate the pot in "The Treasure Hall", from which a narrow way led to our point of departure—the top of the pothole. Above was a fissure providing a passage 20 feet

### *Expedition to the Geldloch*

long, which opened onto the pitch and broadened out into a small chamber in which the pothole installation was now set up.

A number of the cavers were already at work paying out the ladders, for they wanted to get as much material as possible in place that day, so as not to be delayed when the real assault was made; towards evening they returned soaking wet and weary.

"It's very damp and unpleasant at the first pitch," said Albert Morokutti. "It took us a long time and we shall have to stay down there overnight. I suggest that we begin the actual descent the day after to-morrow."

Hubert agreed, and that evening he called a meeting and detailed each man to his post. The most important job was the support of the advance team, so the telephone stations at the mouth of the pothole and the cave entrance had to be occupied. The remaining groups could go about their special duties—surveying, making geomorphological observations, collecting fossils and fauna—but they must always be ready to go to the help of the men at the pitches.

*Midday, July 7, 1953, 09.00 hours.* Koppenwallner, Morokutti, Dr. Oedl, Ginzinger, Wiesler and Zernig disappeared one after the other into the dark chasm of the first pitch. A beam had been wedged between the walls across which ran the ladder and the life-line. The three men on the life-line remained under Heidrich's orders in the fissure chamber. After an hour and a half the last man was down. The full sacks, the telephone apparatus and the necessary cable were lowered.

*11.45 hours.* Now it was the turn of Dr. Hubert Trimmel, Franz Wallisch and myself. While the first team had equipped themselves for a several days' stay in the pothole, with plenty of carbide and provisions, we were to measure the upper part of the shaft and climb up again that evening.

Hubert attached Franz to the rope and the latter slipped over into the first pitch. I followed him on to the supporting beam to help in passing verbal messages.

The abyss below me was pitch black. It was difficult to say where the rock ended and the void began. From below there

## *Wilderness Under the Earth*

was a sound of splashing. A beam of light twinkled in the darkness, occasionally lighting up a small figure for a few seconds. An arm moved in the yellow beam. The taut ladder passed over a jagged rock. The light grew ever fainter. At my side the rope slid over the beam with a slight creak. A confused cry came up from below: "Ee, ecch!" I passed on the signal: "Hold it." The reason for the signal was not clear to me. I could see no acetylene flame; an overhanging wall had probably hidden it from my view. Next a call "Uuh!"; "Pay out", I translated. Once more the ladder at my side seemed to come alive. It was only a hempen rope, but it was a bond with my friend down there; it held him and he entrusted his life to it.

Was that a call?

I listened attentively.

I heard a hardly audible "Eeh!" and after a while, "Aah!" The rope now hung slack. It ran out fast over the beam, now that it was freed from its load.

Hubert started pulling it up, and I grabbed for the end and secured myself to it.

Getting on to a ladder is a decisive moment, like the bracing which the diver must give his body before he leaves the diving board; you leave your secure stance and sink into the unknown. A dark cloud enfolds over you for a brief second, and then you feel the firm ladder, fingers aware of their own strength clutch the rungs, and once more comes a feeling of safety, the joy of taking a risk and the serenity of minutes demanding the highest awareness and preparedness.

I was already a few feet down. The beam retreated, but a light burnt calmly in the darkness overhead—Hubert's carbide lamp as he watched my descent.

I remembered that I had undertaken to give a description of the pitches, so I looked round and tried to light up my surroundings. Sixty-five feet below, the ladder lay against an almost vertical, jagged wall, broken every 5 or 10 feet by ledges; from a bedding joint in the middle one issued a trickle of water which now accompanied me on my further descent. It ceased, like the ladder, at a runnel on the edge of the pitch which gradually took on a triangular profile. Where the wall fell away into overhang, a fine spray fell on me.

### *Expedition to the Geldloch*

As a result of this intermittent dripping, the silty water was distributed over the entire pitch, and the acetylene flame of my lamp was surrounded by a rainbow-coloured aura.

My foot touched ground. Now I saw what had made Franz halt. A ledge ran horizontally right across the wall; the path of the ladder was interrupted, and the small ledge leading to a protuberance where other ladders hung had to be traversed.

Cautiously I looked down below. I estimated that about 65 feet below me there was a pile of boulders, below which I could see Franz's light moving. I climbed calmly down; a bright light had suddenly flashed—Franz had taken a picture of me. Hubert now followed us, and we waited for him crouching against the wall so as to get as little wet as possible.

We looked round. Above us nothing could be seen. The ladder and the telephone cable were swallowed up in the darkness.

The wall down which we had descended opened into a rift and we made for this continuation over a number of wedged boulders. Holes gaped between the rubble. The shaft led deeper here and the platform on which we were standing was formed only of loose boulders.

This was to be seen even more clearly as we progressed. The 9-yard wide rift through which we now climbed had no real floor. A confusion of rocky boulders, blocks as high as houses, had got jammed in the wall, forming terraces over which we could only cross with the help of strips of ladder.

At the end of this gallery was a slickenside of unusual size: the striations due to the rubbing of rock on rock covered the whole of the right cliff wall. In red paint stood the words, "J.H. 1907", a trace of earlier expeditions. Beneath it was a good 16-yard long, roof-shaped block below which the chasm continued.

"Where do we go from here?"

"There's the ladder," called Franz. "On the far edge of the block!"

It was an unpleasant job getting on to this ladder. The rock roof here was very thin; the ladder hung free and swung backwards as soon as the foot was placed on the rung. Nor was there any hold for the hands.

## *Wilderness Under the Earth*

After a few acrobatics, we managed to land on a new platform. Making our way round a bulge in the wall, we came to further pitches and a narrow fissure leading gently downwards. Here we could continue our descent without ladders. The water trickled from the walls, but bulging flowstone bosses and draperies furnished the necessary holds. Finally, the fissure broadened a little, and below were two ledges jutting out from either wall to within a couple of feet of each other. The going was easy here, provided we were cautious.

"Hallo. Who's that?" came a cry ahead of us.

We had reached a spot where two huge jagged spurs were engaged like the cogs of a wheel; from between them peered two dark, flashing eyes. We had reached Wiesler's middle station.

"Cosy here, don't you think?" he asked.

Comfort is a relative concept. The idea that a fissure with a 3-foot wide recess on one side is cosy is certainly a very individual point of view. Wiesler sat in his sleeping-bag for it was the only way to keep warm at 2° C.; a primus stove and his telephone apparatus occupied all the remaining space, and the sheer drop of the abyss was close beside him. From here the pitch led 230 feet downwards, and he had to reckon that at any moment his comrades might need him either to belay them or to lower further material, and he expected to remain there for several days!

Obviously delighted to see us, he made some hot tea and handed round some chocolate.

Franz Wallisch dialled the telephone—one dialling meant, "Calling Cave entrance"; two, "Calling Pothole entrance"; three times was our middle station and four times the advance team.

"Hallo, Anny," Franz called into the mouthpiece. His wife was above at the phone. "We've just arrived at the middle station. What does it look like up there?"

I saw him frown and placed my ear near the receiver.

"Bad weather," I heard. And then a second voice said, "The wireless has just announced thunderstorms." It was Norbert who was at the lower end of the line and who had been listening in.

### *Expedition to the Geldloch*

Fred had once more brought his portable radio and listened to the weather forecast broadcast specially for our expedition. This was the first time we made use of the knowledge we had acquired in the Tantalhöhle that reception is quite good below the ground.

Now we began to take our measurements from here upwards.

*16.15 hours.* A shrill three rings echoed through the chamber. Wicsler took off the receiver. "A thunderstorm had just burst outside," he reported.

*16.47 hours.* Hubert was speaking on the telephone to Norbert when something knocked the receiver out of his hand. A flash of lightning must have struck the line at the entrance. Communication with Norbert remained unbroken, but the two upper stations did not reply.

*17.18 hours.* We continued with our survey, photographing and taking notes on the platform above the calcite chasm. Suddenly there was a fantastic roar. The flood of downpouring rain had reached our level. During the rest of our work, we were accompanied by the muffled noise of rushing water, and, occasionally, the thud of falling boulders.

*17.34 hours.* The roar of the waters increased considerably. When we reached the rubble slopes below the upper pitch, we saw the cause. The mild spray had now become a cascade.

We waited for almost an hour, but things did not improve. The cold was affecting us badly and we began to feel hungry, so I decided to make an attempt at climbing up.

"Calling Pothole Entrance." It seemed an eternity before a voice replied. The noise of the water drowned every word.

"Get ready to belay us," roared Hubert.

An incomprehensible shout came from above. It was repeated until we finally understood. The reply was: "Can't hear you."

At last the men up above realized that they had to belay us. A climb without a life-line would have been madness in these conditions.

Nevertheless, I had to climb 60 feet without a rope to a ledge. It had got caught as the last man descended and we could not reach it from our position. I made it all right, although after

### *Wilderness Under the Earth*

16 feet my lamp went out, but my comrades' lamps gave enough light for me to see where I was.

Hugging the wall and shielded from the wind, I took out my torch, but water was dripping from it and it refused to function. Nor could I relight my lamp. Although I had kept my matches dry, my hands were dripping wet and I could not wipe them, because there was not a dry spot on my overalls. Moreover, the rain poured down on my lamp, so that it would have gone out again immediately even had I managed to produce a flame.

So upwards without a light! The parts above the ledge could not be lit up from below, because they cast a shadow over the beams.

I felt my way over the small ledge towards the hanging ladder end, and now the water caught me with its full force. So far it had been only a heavy cascade, but now it was a cataract. The rope swayed above me, but I managed to reach it. Inch by inch I pulled it towards me. The water ran off it. It was stiff from the damp and I could not tighten the knots with which I fixed it because the hemp would hardly bend.

As I could no longer use my lamp, I attached it by a karabiner to my satchel. "Aah!" I shouted as loudly as possible. Now the return trip could begin. I forced my way upwards against the rushing water. The fellows above hauled damned slowly! They were taking much longer than was necessary; I swayed to and from on the ladder waiting for the pull on the line.

Twelve . . . eighteen . . . twenty-four feet and suddenly the rope was stationary. I tried to shout "Aah!" but the water drowned my cry. My mouth was full of water. Around me was pitch darkness; the water ran into my eyes and I had to keep them closed. I could hear nothing above the thunderous roar. The water ran into the sleeves of my overalls and out of my trouser legs; it was unbearably cold for it had probably flowed over ice higher up. I felt my clothes absorbing the water and growing heavier; in dismay I found that my muscles were getting cramped with the cold and losing their strength.

The only solution was to turn back, but first I must free myself from the rope. I waged a desperate struggle with the sodden knots, but at last they were untied.

### *Expedition to the Geldloch*

I was about to climb down when I realized that a belayed return would be barred to us if the rope ends separated from the ladder and could no longer be reached. As it had stuck and I could not pull it down, I belayed it round a rung. Now I slid more than climbed down the ladder over the ledge and down the ladder to the platform, trembling like an aspen leaf, trying to recover from my exhaustion.

It was some minutes before I could stop my teeth chattering and tell the others what had happened.

"Well, what now?" asked Hubert.

Franz shook his head.

"I dare not stay here in the cold with my wet clothes," I said. "I'd better climb down to Wiesler and drink some of his hot tea. Perhaps the telephone is functioning again. If not, we must try to communicate by cries and the rope must be loosened from above. But the belaying group will have to react more promptly on our upward climb."

Hubert accompanied me down to Wiesler, who lent me a thick, dry coat. The upper telephone line was dead, but it functioned below, and when Wiesler learnt that the advance team had already retired to sleep, he came with us to give a hand.

The downpour had lessened considerably. Franz Wallisch wanted to try the climb first, and he was given the okay by the pothole entrance station, where Heidrich had taken over. A man stood at the edge of the chasm and repeated our signals to him.

We had a few anxious moments, for Franz had to climb unsecured, as I had done, 24 feet from the ledge to the knots where I had belayed the rope to the ladder. He climbed coolly and calmly—not too fast and not too slow—traversed the ledge and once more gained height.

With beating hearts we stared up into the darkness as soon as he was masked from sight by some overhanging ledge.

He alone knows how he managed to undo and retie the knot. It was a great relief when at last we heard his "Aah!" and saw him climb higher. He had blazed a path for us and he gave the man above directions as to the best means of lowering the rope and hauling us to the top.



### *Wilderness Under the Earth*

At last we reached the upper station, while Wiesler returned once more alone to his lonely post.

*Friday, July 10, 1953.* It was three days since the advance team had disappeared underground, but curt telephone calls had kept us informed of their activities.

"Four hundred and thirty yards of new horizontal gallery discovered."

"Pitch discovered at the end station of the 1923 expedition."

"Descending into an unknown chasm in the deepest part."

That evening Wiesler came up for a short spell to recover from the cold. After an hour he returned below, and I accompanied him. I intended to wait with him until the leaders returned.

Until 23.30 hours I photographed in the vicinity of the mid-station, while Wiesler's voice echoed through the chasm singing old folk songs to pass the time. Then I laid out my sleeping-bag at the only free spot next to the abyss, which was separated from the drop by a jagged piece of rock.

Inactivity at a temperature of 2° C., as I have already mentioned, is difficult to bear. My overalls were so wet and mud-stained that I had to strip down to my shirt and shorts. These garments were also wet, but I hoped that they would dry on my body.

I had a long conversation with Wiesler, who told me stories of his Styrian caves. My head lay on a coil of rope and I stared upwards at the jagged walls to the spot where they narrowed. Strange faces seemed to blink down at me from the rock. Monstrous masks of men and animals. . . . The purring of the primus stove grew fainter and Wiesler fell silent after wishing me good-night.

My damp shirt lay like a cold compress on my back. The cold seemed to rise from the floor and give me gooseflesh. The murmur of a little stream babbling somewhere below us rose and fell through the chamber. Suddenly I thought that I heard voices and even understood a few words, but then I could hear nothing, but the roar of water which had made a fool of me.

Gradually my thoughts grew blurred although my faculties were still wide awake. I could feel a dull tension in my head and

### *Expedition to the Geldloch*

the floor beneath me seemed to rise and fall as though tossed by the waves. I felt giddy and the room was spinning round. The floor collapsed and I fell into the void. . . .

*Saturday, July 11, 1953.* I woke at about nine o'clock. I was warm and dry, but Wiesler looked very pale. He confessed that he had not slept a wink because of the cold.

The telephone rang and I took off the receiver. It was Fritz on the line.

"We're coming up to-day," he said. "Get everything ready for the upward climb."

About midday we heard calls from below, and Norbert was the first to appear but hours passed before the last man reached the top and took off his pack. To the pleasure of the returning cavers Wiesler surprised us with one of his tasty dishes—a mountain of sweet noodles cooked in his little pan; it was a mystery to us how he had managed to produce them in such quantities, and I only learned later that the delicious food had been prepared by Fräulein Tönies and Heidrich, and painstakingly transported by Wiesler into the pothole in tins.

Before the ladders were finally hauled up, Fred invited Wiesler and myself to make a short descent in the nearby pitch; unhampered by a load on our backs, this did not take long.

I slipped over the side near our bivouac, reached the ladder, and, held on the line by Norbert, climbed down. The ladder hung completely free 210 feet below in the void. At first I had to get accustomed to the twilight, for our little chamber above had been lit by a number of carbide lamps.

The pitch led down the vertical axis of a gun-carriage-shaped chamber, since lower down a cross joint had been widened out considerably. There was a monotonous roar as water felt its way somewhere in the darkness through the narrow fissures and bedding joints. The ladder swung to and fro giving me a view of a new part of the wall which was curiously grooved, for the abrasive power of the water as it cut through the beds had eaten niches deep into the wall, making it look like an accordion. After ten minutes descent I reached an almost circular ledge half enclosed by a rivulet like a moat; the other half fell into a 110-foot abyss, where it became a cascade.

### *Wilderness Under the Earth*

On my return to the mid-station I found my six comrades drinking a final cup of tea before the last climb.

Fritz spoke of the lowest regions below the section I had just visited.

"It ceases to be a pothole. It is merely a long, deep and rather narrow fissure. The walls often close or are blocked by flowstone which occurs in its most spectacular shapes, and in between the stoppages there are wide chambers so that you have a choice of ways. We came upon two tunnel-like galleries running horizontally through the whole chasm, but the lowest was only a furlong in length.

"We had come to the end of the flight of pitches and chambers. The stream reappeared from narrow crevices. Reinforced by hidden tributaries it had swollen into a mighty brook and finally disappeared into a narrow impassable cleft."

These simple words meant that a 100-year-old objective had been reached: the Ötscher Pothole had been explored to its bottom, 1,686 feet deep. The Geldloch is to-day the eighth deepest cave in the world.

What now followed was the last act of the performance which had been played in the past week on the dark stage beneath the earth's surface. Bodies acted automatically, hand-holds became simplicity itself, holds on the rock face and steps on the ladder rungs were involuntary. It was like a film. The dumping of packs at the top of pitches, the hauling of huge sacks through narrow clefts; Wiesler with cupped hands calling out orders to the men above, hanging in the uppermost pitch with a telephone in one hand, while with the other he tried to free the ladder from a jagged rock.

And then the night scene in the Taubenloch when, long past midnight, the last ladder and the last telephone line had been hauled up. We sat eating and drinking round the open fire with our clothing hanging overhead to dry. The sparks flew when a piece of dry wood was thrown on the embers. Gleaming eyes in emaciated, bearded faces told that that goal had been reached.

## *Chapter Twelve*

### PROSPECTS

THE STORY OF the preliminary research in the Alpine caves is only one small chapter in the history of speleology. Men in other countries are also at work opening up the third dimension of their landscape. One hears very little of the activities of cavers behind the Iron Curtain, but we know that they are active in the Barazdalas Pothole on the Silicka plain in Czechoslovakia, in the Kasprowa Niznia and the Mietusia Cave in the Polish Tatra, and the coastal caves of Belaja in the Urals.

We have more news from the Western hemisphere—the French researches in the Henne-Morte, and the Pierre St. Martin and Caladaire potholes; new discoveries in the Hölloch, the forays of Yugoslavian speleologists in the Predjama system, and the diving attempts of the Italians in the Grotto di Trebiciano near Trieste. Rarely visited limestone regions, waiting to be explored lie in the Atlas mountains, Lapland, Jamaica, Cuba and the Celebes to mention a few.

But the history of caves extends beyond the short period in which one man can personally be active in them. It already began when our ancestors lived in them for thousands of years, generation after generation.

In the last war, munition factories were built in caves as well as ammunition dumps, and from America we learn that limestone caves furnish the best protection against radioactive fall-out.

It is to be hoped that men will not one day be forced to revert to the darkness whence they emerged on the first step to technological victory, and that caves will remain as we see them to-day, places for exploration and discovery.

## SUBJECT INDEX

ALGAE, 61, 116  
 aragonite, 100  
 archaeology, 124, 132, 134, 150f.

BASALT, 72  
 bats, 19, 109, 126, 158  
 bears, 125  
     remains of, 18, 68, 126, 140  
 beetles, 110, 157  
 bivouac hut in cave, 98-99, 104-105  
 breccia, 74

CALCITE, 109, 113, 114, 116f., 135  
 Cambrian period, 86  
 camping in caves, 98-99, 104-105, 192,  
     196-197  
 carbon dioxide, 113f.  
 carbonic acid, 113f.  
 cave animals, 18, 19, 68, 109, 110, 124,  
     125, 126, 131, 140, 157  
 cave lice, 110  
 cave paintings, 152f.  
 cave sanatoria, 124, 127  
 caves, development of, 70f., 88, 134f.,  
     157  
 chalk, (for marking route), 41  
     origin of, 73  
 clay, 72, 97  
 compass, 40, 137  
 compression, 74-75  
 corrosion, 77, 78  
 corrosion, 77-80  
 crayfish, Klutert, 124  
 Cretaceous period, 86-87

DEVONIAN PERIOD, 86  
 Diluvium, 86, 149, 157  
 dolines, 37, 55, 126, 142-143  
 dolomite, 76, 87, 127  
 dripstone, *see* stalactites

ECHOES, 110  
 equipment, 35f., 54, 94  
 erosion, 75-80, 119  
 exhaustion, 111-112

FAULT, 74, 84, 91  
 flooding, 43, 97, 140, 148  
 flowstone, 109  
 food, 58, 60, 92, 97, 98, 104, 192  
 footwear, 36  
 frost, 76

GEOLOGY, 75f., 134, 158  
 glaciations, 86, 87  
 gravel, 100  
 graven, 74  
 gypsum, 73, 76, 119, 120

HEADGEAR, 37

ICE CAVES, 160f.  
 ice, formation of, 166-171  
     light through, 63, 82, 120, 181

KARABINER, 66, 94, 102, 182  
 karst, 76, 81, 85, 123, 143

LADDERS, 37-40, 102, 107, 111  
 life-line, 66, 94, 102, 189  
 lighting equipment, 35  
 limestone, 55, 76, 79, 87, 88, 113f.  
     green, 118

MAGMA, 72  
 methods of caving, 35f., 98  
 mountain milk, 100, 116  
 Mussel Shell Lime period, 86-87

OVERALLS, 36

PALEOBIOLOGY, 134, 158  
 paleogeography, 134  
 Paleolithic period, 126  
 paleometeorology, 135, 158  
 Permian period, 86-87, 120

## *Subject Index*

photography, 137f., 176  
pitons, 40, 137  
pressure flows, 77f.  
proteus, 157

QUATERNARY PERIOD, 86-87

RADIO RECEPTION IN CAVES, 101, 193  
rimstone, 100, 109, 115, 126  
rock collapse, 44-45

SALAMANDER, 131  
sanatoria in caves, 124, 127  
sedimentary rocks, 72  
seepage water, 80-81  
signals, 102, 190, 195  
Silurian period, 86  
slate, 72  
slickensides, 74  
snail shells, 101, 136  
squeezes, 45-49  
stalactites, 32, 101, 102, 107, 109,  
114-115, 117f., 142

stalagmites, 102, 110, 115, 117f., 130,  
142  
static water, 78  
storms, 67, 75, 183, 193  
sumps, 43, 123, 156, 174  
surveying, 58-59

TELEPHONE COMMUNICATION, 59, 189,  
192  
tension, 74  
Tertiary period, 75, 86-87  
tracing rivers, 142  
Triassic period, 86-87

UNDERGROUND LAKES, 119, 120, 166

VADOSE FLOWS, 77  
vortex motion, 78

WATER, 76f., 139, 142, 177  
caves, 81, 125, 140  
weathering, 44, 75, 116  
wind, 76

## INDEX OF PLACE NAMES

- ALB, FRANGONIAN (GERMANY), 127  
     Swabian (Germany), 124  
 Almborg (Austria), 172  
     Ice Cave, Eastern, 138  
     Ice Cave, Western, 172-183  
 Alps, 71, 73, 75, 88-89  
 Altamira (Spain), 151f.  
 Altena (Germany), 121  
 Ameiskogel (Austria), 116  
 Anger Alp (Austria), 164  
 Attendorf (Germany), 117, 121  
 Aussee (Austria), 52, 140  
 Austria, 16f., 46, 52f., 84, 91f., 107f.,  
     116, 138f., 160-186  
 Aven d'Armand (France), 115  
 Aven d'Orgnac (France), 115
- BACKOFEN (AUSTRIA), 160  
 Balverhöhle (Germany), 124  
 Barazdalas Pothole (Czechoslovakia),  
     199  
 Barbarossa Cave (Germany), 120  
 Bärenhöhle (Germany), 113  
     (Torren Falls), 138, 140  
 Baumannshöhle (Germany), 118  
 Belaja caves (U.S.S.R.), 199  
 Bergisch-Gladbach (Germany), 121  
 Bielschöhle (Germany), 119  
 Blue Grotto (Capri), 81  
 Bodenberg (Austria), 37, 85  
 Bricglerskogel (Austria), 68  
     Little, 69  
 Brunnstein Cave (Germany), 128, 130
- CABRERETS (FRANCE), 154  
 Caladaire Pothole (France), 199  
 Cap Blanc (France), 154  
 Capri (Italy), 81  
 Carlsbad Cavern (U.S.A.), 145  
 Casteret Ice Cave (France), 155  
 Charlottenhöhle (Germany), 125  
 Cro-Magnon Cave (France), 154  
 Czechoslovakia, 116-117, 199
- DACHSTEIN (AUSTRIA), 52, 88, 160  
 Dachstein Ice Cave, 160f., 170, 183  
     Mammoth Cave, 46, 160f.
- Dargilan (France), 115  
 Dechenhöhle (Germany), 121
- EASTERN ALMBERG (AUSTRIA), 138  
 Eiskogel Cave (Austria), 170  
 Eisriesenwelt (Austria), 91, 136, 160,  
     170  
 Ennepe valley (Germany), 124  
 Erlaufboden (Austria), 41  
 Erpfingen (Germany), 113, 125
- FALKENSTEIN (GERMANY), 125  
 Feldhof Cave (Germany), 124  
 Fichtelgebirge (Germany), 126  
 Fiume (Rijeka, Yugoslavia), 76, 142  
 Font de Gaume (France), 154  
 Förstershöhle (Germany), 50, 128  
 France, 115, 153-157, 199  
 Franconian Alb (Germany), 127  
     Jura (Germany), 50, 87, 113, 118,  
     126, 128  
 Friedrichshöhle (Germany), 125
- GELDLOCH (AUSTRIA), 84, 184f.  
 Germany, 46, 50, 118-130  
 Grasslhöhle (Austria), 107  
 Great Peggau Cave (Austria), 17-20, 85  
 Grotta di Trebiciano (Italy), 199
- HAGEN (GERMANY), 121  
 Hagengebirge (Austria), 91  
 Hallstatt Lake (Austria), 160  
 Harz (Germany), 118, 120  
 Haselbach (Austria), 107  
 Heiligenkreuz (Austria), 37  
 Heimkehle (Germany), 119  
 Heinrich's Cave (Germany), 122  
 Henne-Morte (France), 199  
 Hermann's Cave (Austria), 46, 139  
     (Germany), 118  
 Hochkönig (Austria), 164  
 Hohe Tauern (Austria), 164  
 Hohen Liet (Germany), 123  
 Hölloch (Switzerland), 113, 117, 144f.,  
     199

## *Index of Place Names*

Holzkechtloch (Austria), 160  
Honnetal (Germany), 121  
Hurben (Germany), 125

ISCHL (AUSTRIA), 140  
Italy, 81-82

JUGOSLAVIA, 76, 138, 142-144, 199  
Jura, Fianconian (Germany), 50, 87,  
113, 118, 126, 128  
Swabian (Germany), 87, 118, 125

KARLSHÖHLE (GERMANY), 125-126  
Kasprowa Niznia (Poland), 199  
Katerloch (Austria), 107, 108, 113  
Kirchberg (Austria), 47  
Kleinhauselhöhle (Jugoslavia), 138  
Klüttert Cave (Germany), 124  
Kohlerhöhle (Austria), 41, 116  
Kohlerwandhöhle, 138  
Kraul Cave (Austria), 160  
Kroatenhöhle (Austria), 116  
Krotten Lake (Germany), 128  
Kyffhauser range (Germany), 118

LACAVE (FRANCE), 115  
Laichingen Pothole (Germany), 125  
Lascaux (France), 153  
Leckkogel (Austria), 55, 58, 68  
Lehenrotte, 138  
Leichenhöhle (Germany), 124  
Les Combarelles (France), 154  
Les Eyzies (France), 154  
Leska (Austria), 107  
Letmathe (Germany), 121  
Little Brieglerskogel (Austria), 69  
Little Peggau Cave (Austria), 20, 117  
Ljubljana (Jugoslavia), 76, 142  
Lueg Pass (Austria), 116, 140  
Lur Grotto (Austria), 31, 43, 47, 115

MAGOCZA CAVE (CZECHOSLOVAKIA),  
116  
Malograjska jama (Jugoslavia), 144  
Mammoth Hole (U.S.A.), 145  
Maximilian Grotto (Germany), 128  
Mietusia (Poland), 199  
Montespan Grotto (France), 155-157  
Montignac (France), 153  
Mork Cave (Austria), 160

NEANDERTAL (GERMANY), 124, 149  
Nebelhöhle (Germany), 125

ÖTSCHER (AUSTRIA), 116, 184f.  
Ice Cave, 138  
Pothole, 84, 177

PADIRAC (FRANCE), 115  
Pech Merle (France), 154-155  
Peggau (Austria), 16, 142  
Cave, Great, 17-20, 85  
Cave, Little, 20, 117  
Pierre St. Martin (France), 155, 199  
Pivka jama (Jugoslavia), 144  
Planina valley (Jugoslavia), 144  
Postojna Grotto (Jugoslavia), 143-144  
Pottenstein (Germany), 127  
Predjama caves (Jugoslavia), 199  
Prince's Cave (Germany), 122

RETTENBACH (AUSTRIA), 140  
Rhineland-Westphalia (Germany), 121  
Rijeka (Fiume, Jugoslavia), 76, 142  
Rubeland (Germany), 118, 119

SALZACH (AUSTRIA), 91  
Salzbuig (Austria), 91f., 116, 164  
Salzkammergut (Austria), 160  
Santillana del Mar (Spain), 152  
Sauerland (Germany), 118, 121-124  
Schachen (Austria), 107  
Scheukofen (Austria), 91  
Schonberg Alp (Austria), 160, 162, 164,  
171-172, 183  
Schonstein Cave (Germany), 113, 128-  
193  
Schwyz (Switzerland), 145  
Semriach (Austria), 31, 142  
Skocjanska jama (Jugoslavia), 143, 144  
Solbad Frankenhäusen (Germany), 120  
Steiger Forest (Germany), 126  
Steyr Lake (Austria), 55, 59  
Streitberg (Germany), 128  
Sundwig (Germany), 122  
Swabian Alb (Germany), 124  
Jura (Germany), 87, 118, 125  
Switzerland, 113, 117, 144-149

TANTALHÖHLE (AUSTRIA), 84, 91f., 117,  
177  
Taubenloch (Austria), 186f.  
Tauplitzalm (Austria), 52  
Tauplitz-Klachau, 52  
Tauplitz Pothole, 52f.  
Pothole, XIII, 59-60  
Pothole, XXVII, 60f.  
Pothole, XXXVIII, 67



## *Wilderness Under the Earth*

Tennengebirge (Austria), 91, 164  
Teufelshohle (Germany), 127  
Torren Falls, 138, 140  
Totes Gebirge (Austria), 52f.  
Tragelhal (Austria), 52-69  
Trageln (Austria), 52, 53  
Trieste, 76, 142

UNITED STATES OF AMERICA, 145  
Urach (Germany), 125

U.S.S.R., 199

WALSCHENFELD (GERMANY), 50, 128  
Warstein (Germany), 121, 123  
Weidensee (Germany), 114  
Weiz, 107, 113  
Wimsen (Germany), 125  
Wuppertal (Germany), 121

YUGOSLAVIA, *see* Jugoslavia.

